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of the

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NORTH AMERICAN WILDLIFE AND NATURAL RESOURCES CONFERENCE

Conference Theme:

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The Wildlife Management Institute wishes to express its appreciation to The Wildlife Society and to the many organizations and individuals who contributed to the success of the 28th North American Wildlife and Natural Resources Conference.

ATTENDANCE RECORD

North American Wildlife and Natural Resources Conferences

Year	*Place*	*Total Registration*	*Banquet Reservations*
1936	Washington, D. C.	1372	------
1937	St. Louis, Missouri	748	------
1938	Baltimore, Maryland	756	412
1939	Detroit, Michigan	813	260
1940	Washington, D. C.	751	336
1941	Memphis, Tennessee	787	------
1942	Toronto, Ontario	339	220
1943	Denver, Colorado	424	305
1944	Chicago, Illinois	502	223
1945	Cancelled	------	------
1946	New York, New York	710	532
1947	San Antonio, Texas	684	503
1948	St. Louis, Missouri	984	687
1949	Washington, D. C.	1203	647
1950	San Francisco, California	1155	494
1951	Milwaukee, Wisconsin	1008	459
1952	Miami, Florida	890	574
1953	Washington, D. C.	1356	975
1954	Chicago, Illinois	960	577
1955	Montreal, Quebec	709	506
1956	New Orleans, Louisiana	926	648
1957	Washington, D. C.	1370	845
1958	St. Louis, Missouri	1013	577
1959	New York, New York	1059	583
1960	Dallas, Texas	890	561
1961	Washington, D. C.	1082	759
1962	Denver, Colorado	1123	660
1963	Detroit, Michigan	1104	526

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PART I

GENERAL SESSIONS

GENERAL SESSION

Monday Morning—March 4

Chairman: ALBERT W. TRUEMAN
Director, The Canada Council, Ottawa, Ontario, Canada

Vice-Chairman: WILLIAM A. KLUENDER
Director, Agricultural and Resource Development Department, Chicago and Northwestern Railway, Chicago, Illinois

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SINEWS OF SECURITY

FORMAL OPENING

C. R. GUTERMUTH

Vice-President, Wildlife Management Institute, Washington, D. C.

It is a pleasure and a privilege to open the 28th North American Wildlife and Natural Resources Conference in this great industrial city of Detroit. The last of these international meetings to be held here was the 4th North American Wildlife Conference, way back in 1939. In checking the transactions of that meeting, it was interesting to note that some of the promising young biologists and administrators who participated in the program 24 years ago are with us at this conference, and most of them have missed very few of the yearly meetings since that time.

At least two who participated in the 1939 program, and possibly more, are scheduled to present papers in this conference. A slender young federal administrator named Albert Day told us what the new Pittman-Robertson Federal Aid to Wildlife Restoration Act was all about, and a handsome young biologist from New York named Gardiner Bump reported on his ruffed grouse studies. Dr. Gabrielson was not as trim then as he is today, and I well remember the waterfowl meeting that he had with the state administrators preceding the conference. A number of others whom I see in this room were on the program of that conference, and many more who listened to those papers are here this morning.

At the same time, there are many in this audience who never have attended one of these international meetings before. So at the risk of boring some of the faithful followers of past meetings, it is necessary to sketch the purposes and procedure for the benefit of the newcomers.

The programs of these annual North American Wildlife and Natural Resources Conferences are developed each year by a rather large committee representing many conservation agencies and organizations, both official and private, from all three of the nations of this continent. The technical sessions are formulated under the direction of a representative of The Wildlife Society, and the Wildlife Management Institute provides the required facilities and stages the meetings.

This is a conference, not a membership convention, and as such, it does not pass resolutions or take action. In this audience around you are many officials of state and provincial agencies, of federal and dominion departments concerned with natural resources conservation and management, and officers and representatives of local, state, and national societies and organizations. They are here to confer, to learn, observe discuss, and debate, but for the most part, they are not authorized to commit their organizations and agencies to any particular position on different issues. Because of this, no resolutions of any kind can be considered or adopted, and the chairmen of the different sessions are requested to rule out-of-order any resolutions that may be presented. The passing of resolutions is left to the discretion of the individual groups here represented.

The sole purpose of this conference is to provide a clearing house of new ideas and new approaches toward meeting the grave conservation problems in this hemisphere. The formal papers on soils, waters, forests, and wildlife should serve as the guidelines for discussion from the floor, and we urge all of you to use the discussion periods scheduled in the program to comment or to question. All that we ask is that any remarks or questions be germaine to the subject of the speaker. The discussion will be recorded and printed in the Transactions.

The Institute hopes that this conference will provide you with fresh ideas and new approaches to the conservation problems that all of us must face either as professional workers in the management of renewable natural resources or as interested citizens. We feel that the program committee has developed an excellent range of subject matter and has provided a distinguished panel of speakers for the next three days.

Before turning the meeting over to the chairman of this morning's session, I have an important announcement. Secretary of the Interior Stwart L. Udall planned to fly here from Washington, to receive the completed report of a special committee that he appointed to study and make recommendations for the handling of the wildlife problems in the national parks. Unfortunately, a last-minute official assignment made it impossible for him to attend. The chairman of the committee, Dr. A. Starker Leopold, will, therefore, present a summary of the report to Assistant Secretary John A. Carver, who will close this morning's session.

Now then, on behalf of the Wildlife Management Institute, I welcome you to the 28th North American Wildlife and Natural Resources Conference and turn the meeting over to a distinguished neighbor from north of the border, Doctor Albert W. Trueman, Director of The Canada Council, from Ottawa, who will preside at this opening general session.

WELL-MANAGED FOREST RESOURCES

F. A. HARRISON

Vice-President Woodlands, Canadian International Paper Company, Montreal, Quebec

I bring you official greetings from the Canadian Forestry Association. I am delighted personally to be able to participate in these discussions.

I will speak as an industrial forester. I have spent virtually all of my business life in the forests of Canada. I have not walked the length and breadth of Canada's 1,700,000 square miles of forests—or even the forests of eastern Canada—but I have walked and paddled and flown over most of the timber lands under the management of Canadian International Paper Company and New Brunswick International Paper Company—approximately seventeen million acres in the provinces of Quebec, New Brunswick, and Ontario. I have hunted the forests and fished the lakes and rivers. Today I am a reluctant urbanite in Montreal, but I go back to the forest every chance I get on business or for pleasure. I think I can still compete in a 50-mile hike if we ever have any in Canada.

Because of this background of mine, I intend to talk to you today about the natural resource I know best: the forest.

Our theme here is "*Natural Resources-Keys to Wealth.*" I would like to emphasize the word "keys." A natural resource is not wealth but *potential* wealth. It can be used badly or well. It becomes wealth when it is used well. The forests of Canada are immensely important to the Canadian economy because of the good use we make of them.

I once heard of a Cree Indian, somewhere in Northern Alberta, who made the point rather neatly.

His name was Michel Bearskin. He was known in the small settlements as something of a wit, an engaging character, dedicated to the theory that work was meant for dogs and, not infrequently, women. But in his own way he was a good provider.

One day he asked a general merchant, a newcomer in that area, if he would stake him to 100 pounds of flour, some sugar, tea and pork. The merchant said he would for a price. But Bearskin had no money, so the talk got around to barter. Finally it was agreed that the merchant would let him have the supplies in exchange for a buck deer.

Months later the merchant happened to meet old Michel on the settlement town's only street.

''Hey!'', he said. ''Where is my deer?''

Whereupon Bearskin replied; ''your deer? I saw him again this morning. He looks fine and fat. He's there in the bush waiting for you. My people won't shoot um. . . . he's yours''.

No doubt the merchant and Bearskin had different conceptions of economics in terms of natural resources, but both knew it had played a role in their little interchange. Maybe Bearskin in his impish way was more of a conservationist than the storekeeper, but it would be a long time before he could again parley a deer running wild in the woods into beans and bacon.

How do the forests rate as a national asset in Canada? By all standards you have to rank them at the very top among our natural resources. For example, the output of pulp and paper in Canada—aside from other forest products—exceeds in value the total annual production of wheat and all other grains combined, and Canada is a big wheat producer. It equals the annual output of all Canadian mines—including precious metals, base metals, iron ore, asbestos, and coal. It is half again as great as the value of Canada's entire automobile output.

To a very great extent, as the forests go so goes Canada.

In discussing the forest resources of Canada—and the United States too because I believe we should think here about the North American continent as a whole—I would like to offer a number of propositions in order to encourage discussion. I will state them briefly and then offer comments. My first proposition is:

1. *The forests of North America must be increasingly well-managed over the years ahead.*

I think the reasons are obvious. It is estimated that the population of the world will increase by 100 million in 1963. In the past fifty years the population of the world has increased by one billion three hundred million. The population of Canada is nearly two and a half times what it was. The population of the United States, Canada's biggest customer, has grown from 102 million to 180 million.

The forest lands have not been expanding in area. In fact, they have been crowded by an expanding urban civilization. In Canada, as in the United States and every other country, expanding roads are often taking away land on which something grew before. About one million U. S. acres are being lost each year to airports, factories, housing, reservoirs, and urban developments. This is land lost forever. The "megalopolis," as they call the city that stretches and expands until one city runs into another, is eating away at the forest lands of North America and the habitat of wildlife.

While we have less productive land area than we did, we have a greater demand for what it can produce. Demand is increasing at a faster rate than population because per capita demand is rising.

Old-fashioned forest management is not good enough. We must grow better forests on less land.

As a *second* proposition I would like to quote the following statement made at the joint meeting of the Canadian Institute of Forestry and the Society of American Foresters two years ago:

2. "*Economics is the great forester. Economics has done more for forestry and foresters in the last fifty years than any other influence.*"

Gifford Pinchot had expressed the same proposition in different words 75 years ago. In 1906, at the first Canadian Forestry Convention, which incidentally was the forerunner of the Canadian Forestry Association of which I have the honor of being president, Pinchot stated his views as follows:

". . . . forestry with us, he said, is a business proposition. We do not love the trees any the less because we do not talk about our love for them, but the owners of the forest lands *in the mass* will never protect their forests for merely sentimental reasons. It has been tried and it has failed. If, however, you can show these owners that it is worth their while to practice forestry, that forest lands can be cut over under methods suggested by a true system of forestry at a profit and with a profit to follow, then you can convince them that forestry is business and therefore worthy of their attention."

Good forest management is expensive. It takes manpower. It becomes possible only when someone can afford it.

Perhaps the most spectacular proof that economics is the great forester and friend of wildlife is to be found in the U. S. South.

In 1935 there were twenty-five pulp and paper mills in the South, and they consumed two and a half million cords of wood per year. The forests of that region had been cut out, turpentined out, and burned out. The old growth had been liquidated. You could buy good forest lands for a few dollars an acre—or less.

Then the pulp and paper industry began to expand in the South and to draw on the southern forests for more and more wood. This had the effect of creating a stable market and raising the economic value of wood. By 1960 there were seventy-three mills, not twenty-five, and annual consumption of wood was more than twenty-three million cords, almost ten times the 1935 consumption.

How great a forester economics turned out to be in the South is clearly shown by the fact that, despite this tremendous increase in consumption under the stimulus of increased demand, the South is better off today in terms of net annual growth in excess of use than at any time in the past 25 years. The cut-over southern forest lands of 1935 were rebuilt and are now healthy, productive forests.

Let me offer another example:

Some years ago one of our company mills at Hawkesbury, Ontario, was first threatened then saved by economics. The mill produced dissolving pulps for viscose and plastics from softwoods. It was high cost. It was unprofitable and could not compete. It had to bring its softwoods in from long distances, and transportation costs were killing the mill.

At this crucial moment the company's research people at Hawkesbury suggested making dissolving pulp—the raw material for rayon and plastics—from local hardwoods. They said it could be done, by transforming the mill—at a cost of many millions.

There was a substantial hardwood supply to be had from the farmers and landowners in this area of rolling country in the foothills of the Laurentian mountains about 80 miles from Montreal—and potentially a great deal more. Like the old southern forests, the Rouge River valley woodlots were not in a healthy state. The best timber had been cut out for the available markets—sawmills and pulp mills. Much of the land had been clear cut in the late years of the preceding century and the early twenties to make way for agricultural crops. Because the land was not suited to these crops, many of the farmers had abandoned their farms or let their fields revert to a wild, uncultivated state.

But the company decided that if it could help the farmers to learn the business of tree farming and provide them with a market for their tree crops, a steady supply of wood for the mill could be developed.

A well-organized wood purchasing program, built around a central wood buying office, largely staffed by graduate foresters, was established first. Then a demonstration and experimental center unique in Canada was created.

Again economics was the best forester. Today that area of Canada is the most highly developed in private forest farms. Of one thousand such farms certified by the Canadian Forestry Association, no less than 163 are located within a 50-mile radius of the Hawkesbury mill.

By finding a way to make the mill profitable, it was possible to make forest farming profitable, and wood began to be grown like a crop. Wood has become one of the principal sources of annual income in the Rouge Valley. During the last twelve years—in this one small watershed—one and a quarter million cords of wood have been delivered to the mill, aside from the saw logs and firewood sold to other markets.

There have been other significant good effects. The services provided by our extension foresters had a profound influence beyond the mere supply of wood to a mill. Our foresters and soil experts and our biologists, operating out of the demonstration farm, spread a gospel of wise land use, which led in 1960 to the formation of the Rouge Valley Association—the first watershed authority set up in the province of Quebec and one of the few in Canada without direct government ties.

The Rouge Valley, one of the most beautiful regions of Canada, never should have been settled for farming at the turn of the century and in subsequent years. Its land was completely unsuited to agriculture except for a few pockets of alluvial tracts. Gradually much of the farming was abandoned and much of the land left in unproductive fallow. The Association's aim is to return this soil to its natural crop of trees and exploit the Valley's other natural resources for fishing, hunting, camping, and tourism. Already several million trees—obtained from the Canadian International Paper Company nursery—have been planted by the Association.

There are other land use projects in Canada. They are proof of our new understanding in the management of resources. We have developed attitudes in keeping with our concept that economics is the great manager. For several years now a special committee of the Canadian Senate has been conducting investigations on land use in Canada. It has heard many briefs presented by a wide variety of conservationists.

Today we have a joint federal-provincial act which should go a long way to restore productivity to underdeveloped or marginal areas. Called the Agricultural Rehabilitation and Development Act, it is intended to restore land given over to marginal farming in the past. In many regions this will mean the development of new forests and improve the habitat for wildlife. It will mean the development of local industries, based on the resources most readily available. The Act will work best with groups similar to the Rouge Valley Association, which will become, in fact, the recognized body to carry out ARDA projects in that particular watershed.

The formation in Canada of a federal department of forestry is a new attitude for Canadians; in our country where provincial rights are jealously guarded, the vital importance of forestry research finally broke through the barrier. Today all Canada can unite behind a national research effort. Economics dictated that this must come about.

I offer as a third proposition one that I think must be central to all planning of forest resources over the years ahead:

3. *Multiple Use is the only policy that makes sense for the future.*

Multiple Use aims at serving all national and local interests to the greatest extent practicable. It means joint use of forests for recreation, leisure, spiritual refreshment—hunting, fishing, picnicking, camping, hiking, skiing—watershed control—as well as industrial purposes.

It therefore means a careful appraisal of the public interests.

In my own company we have given this matter a great deal of thought. As you know, a very large part of the forest domain in Canada is owned by the provinces and is Crown land, leased out for management purposes. Canadian International Paper Company, for example, has management agreements covering some 25,000 square miles of forests—a very large forest farm and a very large responsibility. We are charged with the task of harvesting these lands in accordance with approved plans on a perpetual yield basis. We are responsible for fire protection. Forest diseases are *our* problem.

Public travel in these forests is a matter of direct concern to us. Most of the access roads to forests were built and are maintained by us for harvesting operations. We have built and maintain a network of some 5,000 miles of roads.

Our company policy is quite clear. We fully support the principle of using the forest for all the purposes it can serve, consistent with sound management. Our policy is to permit—and welcome—public travel on company roads for recreation whenever it is compatible with public safety, the safety of woodsworkers, and the sound management of logging operations.

We have declared our belief that in order to develop these values in a sensible way, we must establish a system of priorities that must be observed if the forest is to continue to make its greatest contribution to the economy of the country, while providing as many advantages as are reasonably possible to as many people as possible.

On February 19th last, Edward B. Hinman, president of Canadian International Paper Company, in an address delivered at the annual dinner of the New Brunswick Forest Products Association, made the following statement:

''Of course we have built safeguards into our policy. If we are good managers, if we want to discharge the very responsibilities vested in us by the terms of our leases, we must have these safeguards.

''This attitude of hospitality and welcome, which recognizes the interest of the public in using forest lands for recreational purposes, opens up many fields of cooperation between ourselves and governments, between ourselves and numerous outdoor groups and associations, and between all of these groups and the public.

"Briefly, what we must all cooperate in achieving is a proper, realistic, and balanced use of our forest resources for industrial development as well as for recreational and esthetic purposes.''

There are of course many problems. We can control travel over roads, but regulating airplane travel into the forest is becoming a real difficulty in the vast, uninhabited forests of Canada. At this moment, with so many private planes in use, there is little to stop groups from flying over the forest, choosing any of the thousands of lakes where fish are abundant, landing, and fishing to their heart's content. The more so because they represent an additional fire hazard. Knowing they infringe on property rights, these flying fishermen are always anxious to take off rapidly before they are detected. In these circumstances, who would be bothered putting out a camp fire? A lot of this is going on. It requires controls.

I think a policy of Multiple Use leads inevitably to a final proposition:

4. *There is increasing need for cooperation among all private and public interests.*

The public interest has everything to gain from prosperous forest industries. Government policies should be directed toward making Crown timber lands profitable, helping to control fire and disease, helping to control public use of the forests. We advocate strong forest departments in federal and provincial governments—well-led, well-staffed, and independent.

In New Brunswick and eastern Quebec industry, working with able and far-sighted government leadership, has been able to carry out a ten-year budworm spraying project that has saved a productive forest of many millions of acres at a total cost of $18 million. This would have been impossible without industry-government cooperation. The experiment is important not only because it saved New Brunswick and part of Quebec from a catastrophe but also because it added greatly to our scientific and operating knowledge.

The marginal effects of the spraying on fish and wildlife have been a matter of special study. A final judgment is not yet available, but the scientists are involved in a highly significant exercise in ecology. The forests have been kept alive and in a healthy state. Without spraying, these forests would be dead today and I leave it to you as to what would have happened to fish and game.

Perhaps where cooperation is most needed is in the area of public information and education. People have rights but also responsibilities in the forests. In our handling of visitors into our own timber limits in Canada, we have found many who have an awareness of good forest behavior and have practiced it, but an appalling number seem to ignore even the most elementary rules of forest behavior—rules essential to prevent fire, rules to prevent personal injury and damage, rules to sustain fish and wildlife, and rules of elementary good housekeeping that are just as essential in the forest as they are in our homes and communities.

As more people use the forests, the need for a well-informed and cooperative public will grow. Much of this type of education has been left to voluntary groups in Canada, such as the Canadian Forestry Association, the 4-H Clubs, Boy Scouts, and other groups of young naturalists. I think more is required as we move to develop the recreational wealth of our countries.

The Canadian Pulp and Paper Association quotes a bitter observer who remarked: "Industry can protect forests against misuse by saw and axe and against fires, disease, and ravaging insects. It cannot protect them against fools."

Public policies and sensible regulations, fully endorsed by industry and recreational groups, aimed at a balanced use of our forest resources, and intended to avoid depletion, are the true keys to the forest wealth we have been talking about. Proper implementation of policies of Multiple Use based on public understanding requires cooperation from all of us.

To reconcile the common good with the proper aims of special groups requires the help of organizations like yours and annual meetings like this one. There will always be areas where a forest or a segment of forest should be set aside for single purpose management. That purpose might be industrial, or it might be recreational. But to arrive at decisions regarding such use, we will need the cooperation of all interested people, governments, industry, and recreational groups.

I look toward the future of North American forest resources with great interest and high hopes. The decades ahead of us will, I believe, be a time of progress. Research is telling industry a great deal more than we used to know about the potentialities of a cellulose We can use more varieties of woods in pulp and paper making, for example, than we used to do. We are spreading the burden over a greater number of species. Our operations are more efficient than in the "good old days."

Those were the days of logging camps with such attractive features as muzzle-loading bunks, where you crawled into a double-decker at the foot. A good cook was a great asset because he could make the salt pork and beans bearable. When cutters went into the woods, it was for the duration. They were farmers who went in after harvesting and came out in the spring for planting. The work was back-breaking, the cold as bitter then as now—at least in Canada—and the social life was limited. Boredom and loneliness often sent the men packing for home.

Today our woods camps are modern and efficient, with well equipped kitchens and dormitories. Many of these camps cost up to $200,000 each. We have training schools for camp chefs. We have central food supply depots where we cut our own meat in our own butcher shops and ship it to camp in refrigerated boxes. We contract for the best meat and produce in our cutting areas. We even have nutrition experts and supply our camp cooks with suggested menus. The food is excellent and varied. A worker is likely to get his 5000 or 6000 calories a day in the form of steaks, roasts, several choices of vegetables, home-made bread, and four kinds of pie.

A good many woods workers today motor up to their jobs or go into the woods by bus for the week or even by the day. They go home for the weekends. It is not uncommon to see the camp foreman drive by in his Volkswagen while the woods workers park their Imperials and Cadillacs. I know of woods workers who commute in their own private airplanes.

Cutting today in Canada is done by power saw. And most of the cutters are capitalists. They run their own show. Because they are owners of equipment, they use it well. The modern woodsman is increasingly a trained, experienced professional, and he works under the direction of conservation-minded foresters, who operate from ten-year cutting plans developed with a full awareness that regrowth is an essential part of forest management. Pulp and paper mills cost thirty, forty, fifty million dollars or more to build today. The wood must be there when it is needed. A mill is no good without wood.

We have made great progress in Canada, as you have in the United States, in the past ten, twenty, and thirty years; and our ability to manage the forest resources of the North American continent will improve with the years. The forests can and must continue to grow for the future. They can make possible an expanding economy and at the same time meet the recreational requirements and desires of people such as you and I.

If private and public forces work together toward economically sound forest policies of Multiple Use, and develop the public understanding that is essential, I am optimistic about the good reports which will be made to future meetings of the North American Wildlife and Natural Resources Conference.

(*Mr. Edward A. Weeks, editor of* The Atlantic Monthly, *who was scheduled to present a paper was unable to attend the conference.*)

LAND, PEOPLE, AND RESOURCES

MARION S. MONK, JR.

President, National Association of Soil and Water Conservation Districts, Batchelor, Louisiana

It is a privilege to take part in this 28th North American Wildlife and Natural Resources Conference. These sessions serve a highly useful purpose, providing as they do an annual forum for the presentation of ideas, philosophies, and current knowledge bearing on natural resource problems in our part of the planet.

We need these annual appraisals—particularly since the scope of the Conference has been broadened from wildlife to include the other renewable natural resources.

Conservationists are often taken to task for their innumerable meetings, and for what appears to be a proclivity for "talking to themselves." Granted, we gather together frequently. Granted, too, we address ourselves most often to fellow conservationists who are already "believers." Still, this is not to be interpreted entirely as waste motion or waste voice. None among us has a monopoly on all the facts, nor all the points of view.

Conservation is not yet an exclusive society nor a communist-type tribunal in which the voice of the innovator or the dissenter may not be heard. We need and welcome, here in North America, the new ideas and fresh viewpoints without which the cause of conservation and the necessary development of natural resources could not possibly succeed.

Admitting we have something to say to the world, we still have much to say to each other.

My subject this morning is an item in point. I take it the significant aspect I am to deal with is *People.* Unless I have been consistently deprived of information about this particular field of conservation endeavor during the past 20 years, it is one of the weak points along the conservation front. Certainly we know less about the beliefs, the attitudes, the reactions, and the motivations of people toward their natural resources than we know about the sciences and technology necessary to good management of our resources.

This, of course, is not surprising. The ingredients of science and technology tend to be measurable and, in the end, predictable. People, on the other hand, are measurable only in the most elementary ways and they are highly unpredictable, en masse, over an exceedingly wide array of their actions.

Here, among the democratic nations of North America, this is a matter of critical importance. The voids in our understanding of people represent the weakest links in our coming attack on waste, complacency, ignorance, and default in protecting and developing our natural resources.

Here, among the democratic nations of North America, the ultimate decisions—including those pertaining to natural resources—are assigned to the people themselves. We are committed to the proposition that the people themselves are ready, willing, and able to make wise decisions in their own behalf. We are, in short, committed to the proposition of self-government. We cannot and do not rely on Big Brother, or a Man-on-Horseback, to make the decisions for us.

The supreme value of natural resources lies in their usefulness to people. In turn, this imposes a responsibility on the rank-and-file of people, as well as conservation leadership and scientists, to understand the resources and the full range of their values. It imposes a responsibility to care for the resources, use them wisely, and develop them in an orderly way for the maximum service to society. The situation also imposes a responsibility to anticipate, and estimate as well as we can, the probable demands of people for resources in the foreseeable future.

Although conservation and development of natural resources are accomplished, in part, in the present; there is an undeniable time lag between the vision and the fact. By their very nature and complexity, natural resources cannot be treated summarily. At the risk of using a dirty word, let me emphasize that *planning* is required.

Unfortunately, resource planning has apparently fallen into some disrepute. There are a variety of reasons for this—most of which stem back 25 years to the fear of many in our society that Big Government was going to take over and make a whole series of irremediable decisions that would forever hamstring the operation of private enterprise. The particular villains of that time were the "planners." To this day it is possible to detect an aversion, and even mistrust, of all who profess to find merit in planning that ventures beyond corporate or national defense boundaries.

The essential conservation and development of our natural resources demand planning—advance planning and expert planning—by the best brains we have and with the intelligent support of the people. This does not mean Big Government planning (though governments at all levels must share in the task) but planning that involves the largest possible participation from every responsible segment of our society. Natural resources are that important to our future.

Each of our nations is faced with the fact of limited resources and the prospect of unlimited demands upon them.

This can only mean that the people of our democracies have an obligation to exercise intelligent selectivity in the allocation of available resources to the several alternative uses. The people themselves must provide the mechanism for establishing priorities, because there will not be enough of all resources for all the potential users at the same time in every place.

There must be choices. The people themselves are the only ones, under our system, who can decide. God grant that we will use the wisdom He has given us—and that we not procrastinate!

Characteristically, we tend to act most forcefully and positively in response to imminent crisis. This is not altogether a sign of immaturity, but one must hope that in the latter half of this century the people of North America—and their nations—will act more often on the basis of foresight than fright.

The people have the power in our countries to dispose their future. Coming more particularly to the framework of this conference, let us recognize that the majority of the people have the power to abandon or elevate the future of resource management.

The will of our societies to deal effectively with natural resources is as great a test of our democracies as the relentless confrontation of East and West in the Cold War. Relatively, resource management is a matter of second-class urgency, but it is a first-class test of government by people.

That mystic reservoir of people's strength is, in this trial, far from dry.

There are in being a full score or more of conservation and resource organizations, with citizen membership, to help chart a course. Many of them are represented here today. Great as our aspirations are, I do not believe we should be embarrassed or abashed by the tortoise-like pace of our progress. What is important is converts. The future, let us remember, can be ours. We have a vital cause, well worth fighting for. For all who have faith in the democratic system, the truth of this statement should lend both patience and determination.

There is also in being today, as evidence of the people's strength in dealing with resource problems, a whole array of government laws and programs supporting conservation and resource development—all brought into being by the people through their elected representatives who serve locally, at the state or provincial capitals, and in Ottawa, Washington, and Mexico City. What has already been done can, as needed, be multiplied. We as citizens can, if we make our voices heard, provide ourselves with such additional governmental assistance—and such governmental regulations—as we believe are needed.

There is also in being, in our societies, the avenue to an informed, purposeful, and militant public opinion. To travel this avenue, we must rely on the essential merits of our cause—vying for public attention and public support with all the other myriad worthy movements that compete endlessly for the public mind.

In our preoccupations with the cross-section of terracing and the breeding habits of waterfowl, we have insufficiently addressed ourselves to the task of finding the key to favorable public opinion—and public participation—in behalf of our objectives. A more deliberate search, it seems to me, is an imperative of the resource future. As conservationists, our concern is with a problem truly vast. The public and privately-owned lands and other resources of the continent are vast in all respects. There are millions of individual owners—and even more millions of potential (and actual) users—of these resources. All of us depend, in one way or another, on their productivity, yield, and management. They should be, but are not yet, a matter of universal concern. Nevertheless, the criterion appears plain enough: favorable public opinion on a nation-wide scale is an essential ingredient to the successful realization of most all national or nation-wide objectives.

I trust you will indulge me in a reference to the Association I represent. There are now in the United States some 2,930 individual Soil and Water Conservation Districts—each exercising powers granted by their respective States to develop and carry forward local programs of soil and water conservation (and usually some aspects of flood control). About 14,500 local citizens serve as the governing officials of these Districts. Most of them are elected by their neighbors, all serve without pay, and all represent a citizens' contribution to the public service.

In the neighborhood of 1,900,000 private landowners and operators are cooperating in the programs of these Districts. About one-fourth of their original conservation goal has been achieved. While the accomplishments on the ground have been highly gratifying, the most impressive factor of all is that the people themselves have demonstrated not only a willingness, but a capability, to organize and function cooperatively for both community and national conservation goals.

Every other resource organization represented here can report other examples of useful action generated by or through their membership. All of us can point to the benefits of cooperative endeavor—large and small, public and private. We are making headway—and we are making it because an increasingly important fraction of the people want it to be that way.

Nevertheless, it would be foolhardy to assume that we could count as many as 100,000,000 active conservationists in the United States today. But we need such a majority, and more, if this nation and our sister nations are to make wise decisions about their resources in the years ahead.

We have a vocal, zealous minority of dedicated conservationists leading the way. But we lack public support in breadth, depth, and understanding. Instead of public backing, we have, more accurately, an absence of public opposition.

With the population of the United States approaching 190,000,000, and becoming increasingly city-oriented, this is not good enough and it is risky.

Somehow, far more of the people must be encouraged to join our ranks in a participation that is individually rewarding and nationally beneficial. In this effort we will need help from the political scientists, sociologists, and other experts in human behavior. Biologists are not expected to be knowledgeable about the presentation of issues to New Yorkers—and farmers are not trained in the art of communication to Detroiters. But there are experienced, trained men in every field—men who can be enlisted to help us. There are ways of broadening our base of public understanding.

If it is a cliche to say that the fate of our natural resources resides in the minds of our people, so be it. It is a continuing fact of our democracy that the great and coming tests for conservation and resource development will be tests of responsible leadership.

DISCUSSION

GEORGE HANSON [West Virginia Dept. of Natural Resources]: Mr. Monk, I have to agree in essence with you that we have to get the program in conservation back to the people. We must have their support. We must have their cooperation. I wonder, do you have any recommendations or any suggestions of how we might get the people behind us; how we could get their support; who is going to do the job of getting the information out to them so that they can make their decision and then, how are they going to become mobilized for action to do the job?

MR. MONK: This is a very good question. I was afraid you would ask it.

Sir, I don't know exactly how many conservation organizations there are in America today but there certainly are ample of them. I think the first thing is that it is the job of all of us to tell our friends, our associates. It is certainly more important, in the area of natural resources, more important to the urban population than it is to me, a farmer. I can move on to another little piece of land. Or, I can move on to another job. The urban man pays the price and he doesn't know this.

On a plane last night coming in from New Orleans I was sitting next to a man from Connecticut. He was complaining about the urban sprawl in the area of Connecticut; there was no land left for him. He was complaining about the lack of water. I introduced myself to him. I thought for sure he was bound for this Conference. Instead he was an appliance salesman coming in to his factory for a briefing. These are the kind of people we need to talk to.

On board a plane from Chicago a couple of months ago, I was writing one of my little letters because it had to go to press and a little stewardess looked over my shoulder and said, "What's your connection with soil and water conservation?" Well, I said I was a farmer and I was interested in it and I finally admitted that I had some free title. She gave me a speech that lasted twenty minutes on the need for soil and water conservation. I wish that I could hire this girl because she had done a better job than I could. I found out she had a farm in Arkansas. She was based by Delta in Chicago and she knew the story.

Out of this 190 million people in the United States, we would have to add Canada and Mexico, we need a whale of a lot of people preaching our story.

If each of our conservation organizations would focus our attention on people in the urban areas to tell our story, I think it's going to get told.

I have rambled a little bit and maybe I haven't answered your question. However, we are worrying about the same problem in our organization, and we want the rest of you in your organization to have the same worries that we have.

MR. HANSON: If I may just follow up on that. I am vitally interested in this particular thing because part of my work is with youth groups. It seems to me, and maybe this should be referred to the Conservation Education Section later on in the week, but there are agencies and organizations by the dozens who have educational and informational program and a lot of them are going about helter-skelter and are shotgunning their efforts. Some of us must be crossing our lines. Somewhere along the way we have to get coordinated instead of running off in seven different directions and getting nowhere. We should be pinpointing the different targets as a project rather than a shotgun type of effort.

I don't know who is going to do this job or how we are going to get organized to do it. It certainly should be through some Federal or State organization who should assume this leadership role and get themselves organized to get the job done.

THE JOB AHEAD

IRA N. GABRIELSON

President, Wildlife Management Institute, Washington, D. C.

Resistance to change is predictable. Sometimes it is constructive; sometimes it is not.

Resistance rises from many wellsprings, and its extremes—lack of understanding on one hand and outright opposition on the other—can work both to delay and to obstruct new concepts and programs. Improving understanding and overcoming opposition pose persistent challenges to effective natural resources management, today and in the future. It can be achieved, but it takes teamwork.

An equally formidable challenge confronts each individual interested in natural resources. That challenge is to stimulate and to encourage the search for new ideas, new information, and new means. It requires that all of us, singly and together, must sift continuously through the grains of changing times to find and to nourish the seeds that hold promise of sustaining resources for the public benefit. To do less, in my opinion, would be to fail the trust that has been placed in all resources agencies and in their professional staffs.

I am disturbed to find, more and more, that parochial attitudes and thinking have become a serious deterrent to fitting natural resources, objectives and programs to emerging needs. In one way or another during the past half-century, I have joined with others to strengthen and expand the professional education and training of young people in many resources fields. Within our ranks we now have a large number of admirably trained and dedicated technicians. Despite this progress, there is a pressing need for more men in research, management, and administrative fields of broad interest and vision who have a willingness to communicate new ideas, to provide leadership in forming public opinion and in winning essential support.

Professionalism does not mean that contacts should be severed with the social, economic, and political forces that have had and always will have important bearing on natural resources decisions. The technical and professional societies should be mindful of this danger, this drift to passive specialization. I urge them to strive to create more opportunities for a broader resources outlook in education and training programs. Today's tremendous resources demands will be infinitely more complex tomorrow. We dare not lose contact with reality. We need men fully equipped to interpret, to guide, and to lead.

Let me give an example. Nationally, a huge groundswell is mounting for outdoor recreation of all kinds. Studies in some states and the conclusions of the Outdoor Recreation Resources Review Commission show that a very considerable part of the recreation demand is oriented toward water and fish and wildlife. Some imaginative state recreation programs already are firmed and others are under consideration. Fish and wildlife have considerable part in them. The Federal Government is striving to get a new outdoor recreation program going, and one of the recommended proposals, the land conservation fund, could yield financial support to state programs far in excess of foreseeable revenues from license fees. Fortunately, some administrators are in the vanguard, offering leadership and striving to insure that fish and wildlife get the attention they deserve in any national program that is developed. There are others, unfortunately, who appear to prefer to stand in the wings and grumble and criticize. They apparently see no value, no opportunity, in identifying or associating fishing and hunting with the tremendous national appetite for outdoor recreation.

Seldom, in my experience, have we been offered a major role in a campaign that has so much popular support and so much chance of success. Political, financial, and public support are assured. People are interested in outdoor recreation, and in many states it is the fish and wildlife department that is in the most favored position to serve them. I hope this challenge will be accepted.

Paralleling our obligation to build is an obligation to prevent destruction. Sometimes they go hand in hand, as in the case of the Bureau of Land Management, to build by preventing destruction. Here, we are confronted by adversaries of old—those few people who hold permits and licenses to graze livestock on the national land reserve and who want to freeze their already considerable public lands privileges into permanent personal rights. They want a free hand in putting public land to private use, on their own terms, at the least possible expense and with the least interference. They want to avoid paying the fair market value for the forage their livestock consume and the cost of restoring the rangelands their operations destroy.

The politically minded segment of the grazing permittees is a formidable and patient opponent. They are going to put their brand on much of the 180 million acres of public lands in the West unless the millions of people who live in this country begin to insist in a louder voice that their interests be given some consideration.

The fee that permittees have been paying to graze one animal for one month on the national land reserve is ridiculous. Until just a few days ago, when Secretary of the Interior Stewart L. Udall and Assistant Secretary John A. Carver, Jr. refused to bow to congressional pressure and raised the grazing fee to 30 cents an animal unit month, the livestock permittees were paying 19 cents. In round figures, and for comparison, the Forest Service charges 60 cents; the Indian Bureau and the Bureau of Land Management itself, in non-grazing district areas, charge $1.25 and up. The commercial rate is $3.00 and up.

Secretary Udall and Assistant Secretary Carver deserve the support of all conservationists for having the backbone to exercise the authority that is theirs under the terms of the Taylor Grazing Act and to adjust the grazing fee. The fee is still too low for the forage and other values received, but the raise is a step in the right direction. The increase now means that the permittee will pay the Federal Government a sum equivalent to the price received for 1½ pounds of each cow that has been on the national land reserve for a month.

Don't be misled. As keenly as it is contested, the grazing fee controversy is mostly a sham. It masks the permittee's real interest in grazing district lands. What the noisy permittee really wants can be outlined clearly. He wants no interference with his use of the federal range. He wants no reduction in the number of animals that his permit says he may graze on the range. The fact that reduced grazing intensity may be necessary to protect the range from gullying and erosion is of no concern. Eroded and weed-infested ranges can be blamed on fire, drought, and federal finagling. The federal grazing permit attaches a considerable value to the livestockman's base ranch. It is sold with the ranch. The rancher wants to maintain that paper value of his ranch.

Secondly, the rancher makes a plea for freedom from government supervision so that he can be assured that his ranching operation will be stable. The present 10-year permits, he says are insufficient They should be increased to 20 or more. In the absence of facts, that plea may strike a sympathetic chord, but don't be misled. Permittees who run livestock on the grazing districts under the Taylor Grazing Act have a monopoly. The forage on federal rangelands has been fixed to the same private ranches since 1934 at least. Outsiders can't get in unless they buy the base ranch to which the grazing allotment attaches. There is no competition; the forage is sold at a ridiculously low rate, and there isn't any bidding. Expressed on a receipts-per-acre basis, other agencies have been getting from 200 to 1,875 per cent more than BLM for forage on lands that are intermingled with state and private grazing property.

Grazing district permittees aren't talking about stability—they're talking about securing a public resource for their permanent use.

There is lots of talk about new frontiers these days. One of the greatest resources opportunities for a new frontier is in the Bureau of Land Management, which administers 180 million acres in the West excluding Alaska. It is shackled by outmoded concepts and dusty laws. Few people, including members of Congress, realize how valuable the national land reserve really is. Few realize that the BLM is about the best money maker the Federal Government has. Over the years, BLM lands have returned more than $7 for every $1 appropriated to administer them. It returned $1 billion to the Federal Treasury in 10 years.

Despite this excellent record, some people are saying that the nation really can't afford the national land reserve, that the BLM shouldn't hire more qualified resource specialists, that a range technician who has a responsibility for more than 2 million acres shouldn't have a 2-way radio in his car, and that range rehabilitation erosion control, reforestation and fire suppression are unnecessary because BLM administers only useless desert, something that no one wants. Nothing could be further from the truth.

Take the question of outdoor recreation that I mentioned earlier. Some of the country's outstanding outdoor slums are on the national land reserve. The reason is simple and the blame is clear. No Administration and no Congress ever has faced up to the fact that BLM should be running a recreation program. In the past two years the BLM has not had $1 to do anything for outdoor recreation. It can't build picnic tables, fireplaces, sanitary facilities, or water taps. It can't even pick up the debris and litter at the places that are getting heavy recreation use—and many are.

The Outdoor Recreation Resources Review Commission confirmed that most Americans get their outdoor recreation a day's drive or less from home. In the West the national land reserve goes up to the outskirts of community after community. The land is already there, in public ownership, but a nearsighted outlook and a Pleistocene philosophy prevent the development of suitable areas for outdoor recreation. In the horse-and-buggy situation of the national land reserve, it is still easier for one man or one corporation to get hold of a choice recreation area under a bogus mining claim than it is for a family to find a picnic table.

Conditions are now developing for a face-to-face encounter over the national land reserve. The chairman of the House Interior and Insular Affairs Committee is committed to what he calls an intensive probing into the legislative-executive jurisdiction over the public lands. A subcommittee chairman in the companion Senate committee is promising an investigation of the operations of the BLM.

Various bills already have been introduced to create a public lands study commission, to give the BLM a multiple-use policy declaration similar to that of the Forest Service, to revise outmoded laws, and to create a special board in the Interior Department to act on appeals from BLM land decisions. More legislation most likely will follow, and I cannot urge too strongly that conservationists keep themselves up-to-date on all the developments. Change is in the wind, and whether it blows good or bad may be up to you. The stakes are important and the situation is tense.

Recently, the Nevada State Legislature, a body including a goodly number of public lands grazing permittees, officially resoluted that the BLM is a "tapeworm of the livestock industry." I hardly need remind the biologists in the audience that political leeches can be classed as parasites, too.

Aside from the more obvious opportunities for change, specific situations have not changed greatly in the last year. Some progress has been made, here and there, and most of it has been reported fully. Someone asked me not long ago for suggestions about new matters that might benefit from legislative attention. One or two things can be singled out, but I am forced to admit, quite frankly, that we have reached the point of genuine political frustration on so many worthy issues that the resolution of just a few certainly would be something new.

Despite all the national furor, for example, there still is little effective information to guide the safe field use of highly toxic chemicals in agriculture, forestry, and other pest control programs. The rapid appearance of new products on the market continues to dwarf all hope for improved understanding. Essential research doesn't lead, it barely follows.

We must learn more about the effects of those poisons on food chain organisms, and on the pathology and reproduction of all animals. Greater effort is needed to test and to identify new chemicals. The whole testing program of the Bureau of Sport Fisheries and Wildlife should be expanded. Candidate chemicals must be tested and evaluated well before the manufacturers commit large expenditures for development. It is the press of that financial investment that is forcing some products on the market.

The need for accelerating bird research is obvious. The Bureau is unable to provide the information about satisfactory methods for controlling any number of pest species or of helping valuable ones. Waterfowl remain a continuing problem, but the acute need to overcome habitat destruction should not preclude the search for information about improving the usage of existing habitat as well as exploring methods of getting waterfowl production from stock and farm ponds. Congress must devise an acceptable refuge revenue sharing formula that will get county governments to support, rather than block, the wetlands acquisition programs.

I have serious question about the prevailing philosophy that restricts wildlife research activities of the Bureau largely to migratory game forms. There are plenty of avenues of research on both nongame migrants and resident species that the Bureau can perform that would benefit both state and federal programs. Wildlife research work of necessity is becoming increasingly complex and the knowledge that is required is beyond the abilities of the wildlife biologists in many respects. Chemists, physiologists, biostatisticians and others are needed, and their services are expensive to secure. The reservations about federal research appear more imaginary than real. The Bureau at least has some of these technicians and should have more.

An old problem, but with a new stumbling block, involves the Department of the Interior and the Bureau of the Budget, the President's fiscal monitor. The Budget Bureau is maintaining that duck stamp funds should be used to pay for lands acquired at federal impoundments for fish and wildlife purposes. Secretary Udall contends, and I think rightly, that the Budget Bureau is not correct.

He can point to the fact that the Federal Government undertook the responsibility for migratory bird resources 18 years before there was a duck stamp. He can show the Fish and Wildlife Coordination Act that stipulates that fish and wildlife are to be equal partners with all other project purposes at federal impoundments. The Budget Bureau's position also runs counter to two policy statements approved last year by the President. One specifies that the Interior and Army Departments can buy lands around reservoirs for public access, fish, wildlife, and recreation. The other instructs several federal agencies that "Planning for the use and development of water and related land resources shall be on a fully comprehensive basis so as to consider . . . outdoor recreation, as well as sport and commercial fish and wildlife protection and enhancement; preservation of unique areas of natural beauty, historical, and scientific interest . . ."

The Budget Bureau's stand, if sustained, would make mockery of the $105 million wetlands acquisition loan that is to be repaid from future duck stamp sales. It would mean again that a small element of the public would be saddled with paying the bill for all. It contradicts the land conservation fund proposal, approved by the President, and now in Congress, that provides that part of the fund's receipts would be deposited in the Treasury to help offset the costs of acquisition of lands for recreation and fish and wildlife enhancement at federal and federally assisted water projects.

Another matter, long in need of resolution, involves efforts to permanently dedicate the Tule Lake, Lower Klamath, and Upper Klamath National Wildlife Refuges in Oregon and California for wildlife purposes. Created by Executive Order, those refuges never can be considered secure until Congress removes the temptation they hold for the farmer and the land speculator. Bills to accomplish this have been introduced in both the House and Senate, and they merit your study and support. I can tell you here that considerable concern is developing over Section 7 in the identical bills introduced by California's Senator Engle and Congressman Johnson, which differ from all of the others. No thinking person, to my knowledge, seeks to interfere with present agriculture leasing in the Tule Lake refuge. But at the same time, it is necessary to make sure that in protecting valid interests of the farmers, the refuge isn't exposed to more of their attempts, such as in 1959, to ruin it by tampering with the water levels.

A vital new concept, that recreation is compatible with other resources uses, is being molded by the report of the Outdoor Recreation Resources Review Commission and by the establishment of the new Bureau of Outdoor Recreation. The wider this concept spreads and the more its implications are recognized and put to work the better. It is time that the nation turned away from the long-held, restrictive concept that recreation precludes all other resources uses. The ORRRC report and subsequent developments illustrate the inadequacy of the old piecemeal approach to attempting to meet local, state, regional and national recreational needs. A coordinated approach to outdoor recreation planning and programming is not fiction. It is necessity.

Time will not permit further elaboration, but I do want to single out the wilderness bill as a deserving measure. It passed the Senate 78 to 8 in 1961, but was strangled by legislative stratagem in the House last year. As you all know, the House committee emasculated the good Senate bill and then endeavored to force the House to vote on a take-it-or-leave-it basis. When the House refused, the chairman left Washington three weeks before the session ended. This killed this bill and several other good conservation measures. The Senate undoubtedly will pass the measure again this session, and it is going to require considerably more groundwork than before to prod an unfriendly House Interior and Insular Affairs Committee to report it out to the full House where there is considerable support for a good wilderness bill.

Check, too, the bills that would accommodate a special purpose by creating national park or recreation units at such places as Indiana Sand Dunes, the magnificent Sleeping Bear Dunes, Ozark Rivers, C & O. Canal, Oregon Dunes, and the Prairie and Canyonlands National Parks.

Study also the new Blatnik-Dingell-Muskie water pollution bill that would create a separate administration within the Health, Education, and Welfare Department. Conservationists have been seeking this for years. They want pollution handled as a water resources matter, not as a public health problem. Look also at the policy declaration in the bill that says that the national objective will be to keep the waters as clean as possible—not to load them with pollutants up to their maximum assimilative ability.

No stranger to most of you is the continued threat to fish and wildlife from various suggested dams and impoundments. There is a new proposal now for a project that dwarfs all previous projects in the unprecedented magnitude of fish and wildlife resources and habitat that would be destroyed.

It is the proposed Rampart Dam on the Yukon River in central Alaska. Get acquainted with this proposal and you will find beneath its glossy surface a massive and irreparable threat to fish and wildlife.

The 500-foot dam would block sizable upstream migration of salmon in the Yukon. The Rampart impoundment would cover 10,000 square miles—I said square miles—of the Yukon Flats that produce on the average of 1 million ducks and geese a year. More ducks are produced there than are bagged in most flyways. They represent millions of man-days of recreation in all states, because Yukon Flats waterfowl are bagged in all flyways, from the Pacific to the Atlantic. Moose and furbearers also would suffer, and the dam would alter the annual water cycle that makes the Yukon Delta an important waterfowl breeding and concentration ground.

Rampart Dam is synonymous with resources destruction. A very determined effort is being made to speed up the studies and rush its authorization through Congress, and conservationists everywhere had better look into the proposal and learn the facts that are involved.

The 1962 Food and Agriculture Act offers opportunities to landowners and to state agencies for the development of recreational facilities and fish and wildlife habitat on private lands. All sorts of low-interest, long-term loans and, incentive, cost sharing, and practices adjustment payments are being offered. For the first time, recreation of all kinds is being viewed as a justified expenditure of public funds in agriculture programs. Further opportunities are offered under the small watershed program and rural renewal and area redevelopment.

State conservation agencies should study these programs carefully, and consult with agriculture groups to see if there is a role for them in increasing public understanding of the available financial and technical assistance. The Department of Agriculture has estimated that 50 million fewer acres will be needed in crop production in coming years. How much of this land is devoted to recreation and fish and wildlife depends on how well the private landowners are acquainted with the benefits that can be derived. The leadership of the experienced state fish and game departments is badly needed.

These are some of the things that must be done. It isn't spectacular work, and the wages aren't high, but the rewards are great. It is the plodding, studious, sincere work that involves increasing understanding and overcoming opposition. It is the intensive kind of work that will insure that resources will be available for the future enjoyment and benefit of the people. It is our job that lies ahead.

DISCUSSION

MR. JAMES CRAIG [American Forestry Association]: We would like to endorse what Dr. Gabrielson just said in reference to the "backflow."

There is another facet to this proposition though that might be mentioned and that is the reluctance of Congress in the past to appropriate funds for research for BLM programs. In this connection, our association has become quite interested in Senator Anderson's Bill which would provide funds for research in colleges and other public schools that would enable the Interior Department to perhaps do what the agricultural research agents and other groups have all done for agriculture and related programs.

We think this is part and parcel of research, which mustn't be overlooked in this program to rehabilitate the land. We hope you all devote some attention to this particular bill.

MR. PAUL DAVERS: Your address mentioned that part of the job ahead was to develop and train people. We have added an undergraduate program to train these people but we have hit certain snags in getting employment for these graduates.

Our program, for instance, is designed to do work at grass roots level rather than top levels. Our program includes work in forestry, soils, water, wildlife and other things. We have supporting courses such as economics, conservation and the law, resources policies, and many others.

We are quite concerned about this fact that the agencies, and other organizations, seem reluctant to employ people with this kind of a background. I would like to know whether you agree that there is a niche for undergraduates with this broad training.

Too, I would like to know your ideas on the support and how we should proceed with a program of this sort to make it successful.

DR. GABRIELSON: I would agree very much, if I understood the statement, that there is a need for undergraduate training on this broad basis. I wish that all of the fellows that specialized in wildlife could have that kind of training before they go on to specialize.

There is a growing need for that kind of people in many agencies. If you will sit down after this meeting and talk with me, maybe I can tell you where some of them are. There are places where people are looking for men with that kind of background. These are the kind of men that I am talking about with a broad background who have gained knowledge and experience and become leaders in the broad conservation field instead of specializing.

We have done much in training specialists up to now, but we haven't done much in training men for future leadership on a broad conservation basis.

MR. BUD BODDY [Alaska]: I would just like to comment on Dr. Gabrielson's reference to the Rampart Dam. I'm very pleased that he brought this matter to your attention at this time because it is a very serious matter and one which I would join him in urging that everyone seek out all of the information of a factual nature you can get in regard to the overall effect of this proposed structure on the great State of Alaska and the effect it will have on people of the whole United States of America.

This is being pushed rapidly. Ordinarily, they plan seven to nine years for the investigation. It appears they're going to try and close out at least with this year's operation, which is entirely too soon in our opinion. Thank you.

MR. ELLIOT BARKER [Santa Fe, New Mexico]: I would like to ask Dr. Gabrielson if he would suggest to these good people here what they can best do now to promote the passage or at least reporting of the Wilderness Bill out of the Senate Committee. What is the immediate step that we can all take?

DR. GABRIELSON: That is very simple to answer. I don't have a list of the Senate Committee here, but it is a much more favorable committee than the House Committee because we have a lot fewer western Congressmen on it. A lot of you folks from Colorado could help them out quite a bit if you would send one Congressman home (laughter).

The best thing you can do is to get after your Senators, whoever they are, and get them to do something more than say "I'm for this Wilderness Bill." Whenever you get one Senator, outside of a Committee, going to the Committee and saying that he wants something done and that he wants a chance to appear before the Committee to support the Bill, this helps. If you get two or three Senators doing that, it helps a lot more. If you get half a dozen, you're almost a cinch to get a hearing. The House is certainly going to be a lot rougher because we have a pretty hostile committee there. I think the vote is about three to one against it. Just what the conservationists are going to do about that, aside from some providential intervention, I don't know, but we are going to keep working on it.

It wouldn't hurt to have your Congressman, starting right now, go to work on that House Committee for hearings on the Wilderness Bill. We were in hopes of getting a decent bill out of that Committee but if we get any bill on the floor we at least have a chance to pass some kind of a Wilderness Bill in the House. I think there are enough votes there to amend it and improve it a lot. We would also have a chance to improve it in conference.

So, it is not too early to get after this thing.

STUDY OF WILDLIFE PROBLEMS IN NATIONAL PARKS

A. STARKER LEOPOLD

Chairman, Special Advisory Board on Wildlife Management for the Secretary of the Interior; Professor of Zoology, University of California, Berkeley

March 4, 1963

The Honorable Stewart Udall
Secretary of the Interior
Dear Mr. Secretary:

Your Advisory Board on Wildlife Management transmits herewith a report entitled *"Wildlife Management in the National Parks."*

In formulating the conclusions presented in this report, the Board made a major effort to familiarize itself with actual conditions in the parks and monuments. The full Board visited Yellowstone and Grand Teton National Parks where the elk situation has been acute. Individual Board members inspected a number of other parks which in the judgment of the National Park Service have current wildlife problems. Between us in the last few years we have seen nearly all of the major parks and monuments, including those in Hawaii and Alaska. Our recommendations are based principally upon our knowledge of the parks and their problems.

Additionally, we have endeavored to understand and to evaluate the full spectrum of opinions and viewpoints on park management. In September at Jackson Hole the Board met with five directors of state game departments. In December in Washington we met with five executive officers of conservation organizations. Many other individuals and groups have offered advice and information. All of this was informative and helpful, but we want to make clear to you that our conclusions were not reached by weighing opinions and counter-opinions. The conclusions represent our own collective thinking.

The report as here presented is conceptual rather than statistical in approach. We read thousands of pages of reports, documents, and statistical tables, but used these data only sparingly to illustrate specific points. Emphasis is placed on the philosophy of park management and the ecologic principles involved. Our suggestions are intended to enhance the esthetic, historical, and scientific values of the parks to the American public, vis a vis the mass recreational values. We sincerely hope that you will find it feasible and appropriate to accept this concept of park values.

Respectfully submitted,
Stanley A. Cain
Clarence M. Cottam

Ira N. Gabrielson
Thomas L. Kimball
A. Starker Leopold,
Chairman

WILDLIFE MANAGEMENT IN THE NATIONAL PARKS

Advisory Board on Wildlife Management,
appointed by Secretary of the Interior Udall

A. S. Leopold (*Chairman*), S. A. Cain, C. M. Cottam, I. N. Gabrielson, T. L. Kimball

HISTORICAL

In the Congressional Act of 1916 which created the National Park Service, preservation of native animal life was clearly specified as one of the purposes of the parks. A frequently quoted passage of the Act states ". . . . which purpose is to conserve the scenery and the natural historic objects and the wild life 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."

In implementing this Act, the newly formed Park Service developed a philosophy of wildlife *protection,* which in that era was indeed the most obvious and immediate need in wildlife conservation. Thus the parks were established as refuges, the animal populations were protected from hunting and their habitats were protected from wildfire. For a time predators were controlled to protect the "good" animals from the "bad" ones, but this endeavor mercifully ceased in the 1930's. On the whole, there was little major change in the Park Service practice of wildlife management during the first 40 years of its existence.

During the same era, the concept of wildlife management evolved rapidly among other agencies and groups concerned with the production of wildlife for recreational hunting. It is now an accepted truism that maintenance of suitable habitat is the key to sustaining animal populations, and that protection, though it is important, is not of itself a substitute for habitat. Moreover, habitat is not a fixed or stable entity that can be set aside and preserved behind a fence, like a cliff dwelling or a petrified tree. Biotic communities change through natural stages of succession. They can be changed deliberately through manipulation of plant and animal populations. In recent years the National Park Service has broadened its concept of wildlife conservation to provide for purposeful management of plant and animal communities as an essential step in preserving wildlife resources ". . . unimpaired for the enjoyment of future generations." In a few parks active manipulation of habitat is being tested, as for example in the Everglades where controlled burning is now used experimentally to maintain the open glades and piney woods with their interesting animal and plant life. Excess populations of grazing ungulates are being controlled in a number of parks to preserve the forage plants on which the animals depend. The question already has been posed—how far should the National Park Service go in utilizing the tools of management to maintain wildlife populations?

THE CONCEPT OF PARK MANAGEMENT

The present report proposes to discuss wildlife management in the national parks in terms of three questions which shift emphasis progressively from the general to the specific:

1) What should be the *goals* of wildlife management in the national parks?

2) What general *policies* of management are best adapted to achieve the pre-determined goals?

3) What are some of the ***methods*** suitable for on-the-ground implementation of policies?

It is acknowledged that this Advisory Board was requested by the Secretary of the Interior to consider particularly one of the methods of management, namely, the procedure of removing excess ungulates from some of the parks. We feel that this specific question can only be viewed objectively in the light of goals and operational policies, and our report is framed accordingly. In speaking of national parks we refer to the whole system of parks and monuments; national recreation areas are discussed briefly near the end of the report.

As a prelude to presenting our thoughts on the goals, policies, and methods of managing wildlife in the parks of the United States we wish to quote in full a brief report on "Management of National Parks and Equivalent Areas" which was formulated by a committee of the First World Conference on National Parks that convened in Seattle in July, 1962. The committee consisted of 15 members of the Conference, representing eight nations; the chairman was Francois Bourliere of France. In our judgment this report suggests a firm basis for park management. The statement of the committee follows:

"1. Management is defined as any activity directed toward achieving or maintaining a given condition in plant and/or animal populations and/or habitats in accordance with the conservation plan for the area. A prior definition of the purposes and objectives of each park is assumed.

"Management may involve active manipulation of the plant and animal communities, or protection from modification or external influences.

"2. Few of the world's parks are large enough to be in fact self-regulatory ecological units; rather, most are ecological islands subject to direct or indirect modification by activities and conditions in the surrounding areas. These influences may involve such factors as immigration and/or emigration of animal and plant life, changes in the fire regime, and alterations in the surface or subsurface water.

"3. There is no need for active modification to maintain large examples of the relatively stable "climax" communities which under protection perpetuate themselves indefinitely. Examples of such communities include large tracts of undisturbed rain-forest, tropical mountain paramos, and arctic tundra.

"4. However, most biotic communities are in a constant state of change due to natural or man-caused processes of ecological succession. In these "successional" communities it is necessary to manage the habitat to achieve or stabilize it at a desired stage. For example, fire is an essential management tool to maintain East African open savanna or American prairie.

"5. Where animal populations get out of balance with their habitat and threaten the continued existence of a desired environment, population control becomes essential. This principle applies, for example, in situations where ungulate populations have exceeded the carrying capacity of their habitat through loss of predators, immigration from surrounding areas, or compression of normal migratory patterns. Specific examples include excess populations of elephants in some African parks and of ungulates in some mountain parks.

"6. The need for management, the feasibility of management methods, and evaluation of results must be based upon current and continuing scientific research. Both the research and management itself should be undertaken only by qualified personnel. Research, management planning, and execution must take into account, and if necessary regulate, the human uses for which the park is intended.

"7. Management based on scientific research is, therefore, not only desirable but often essential to maintain some biotic communities in accordance with the conservation plan of a national park or equivalent area."

THE GOAL OF PARK MANAGEMENT IN THE UNITED STATES

Item 1 in the report just quoted specifies that "a prior definition of the purposes and objectives of each park is assumed." In other words, the goal must first be defined.

As a primary goal, we would recommend that the biotic associations within each park be maintained, or where necessary recreated, as nearly as possible in the condition that prevailed when the area was first visited by the white man. A national park should represent a vignette of primitive America.

The implications of this seemingly simple aspiration are stupendous. Many of our national parks—in fact most of them—went through periods of indiscriminate logging, burning, livestock grazing, hunting and predator control. Then they entered the park system and shifted abruptly to a regime of equally unnatural protection from lightning fires, from insect outbreaks, absence of natural controls of ungulates, and in some areas elimination of normal fluctuations in water levels. Exotic vertebrates, insects, plants, and plant diseases have inadvertently been introduced. And of course lastly there is the factor of human use—of roads and trampling and camp grounds and pack stock. The resultant biotic associations in many of our parks are artifacts, pure and simple. They represent a complex ecologic history but they do not necessarily represent primitive America.

Restoring the primitive scene is not done easily nor can it be done completely. Some species are extinct. Given time, an eastern hardwood forest can be regrown to maturity but the chestnut will be missing and so will the roar of pigeon wings. The colorful drapanid finches are not to be heard again in the lowland forests of Hawaii, nor will the jack-hammer of the ivory-bill ring in southern swamps. The wolf and grizzly bear cannot readily be reintroduced into ranching communities, and the factor of human use of the parks is subject only to regulation, not elimination. Exotic plants, animals, and diseases are here to stay. All these limitations we full realize. Yet if the goal cannot be fully achieved it can be approached. A reasonable illusion of primitive America could be recreated, using the utmost in skill, judgment, and ecologic sensitivity. This in our opinion should be the objective of every national park and monument.

To illustrate the goal more specifically, let us cite some cases. A visitor entering Grand Teton National Park from the south drives across Antelope Flats. But there are no antelope. No one seems to be asking the question—why aren't there? If the mountain men who gathered here in rendezvous fed their squaws on antelope, a 20th century tourist at least should be able to see a band of these animals. Finding out what aspect of the range needs rectifying, and doing so, would appear to be a primary function of park management.

When the forty-niners poured over the Sierra Nevada into California, those that kept diaries spoke almost to a man of the wide-spaced columns of mature trees that grew on the lower western slope in gigantic magnificence. The ground was a grass parkland, in springtime carpeted with wildflowers. Deer and bears were abundant. Today much of the west slope is a dog-hair thicket of young pines, white fir, incense cedar, and mature brush—a direct function of overprotection from natural ground fires. Within the four national parks—Lassen, Yosemite, Sequoia, and Kings Canyon—the thickets are even more impenetrable than elsewhere. Not only is this accumulation of fuel dangerous to the giant sequoias and other mature trees but the animal life is meager, wildflowers are sparse, and to some at least the vegetative tangle is depressing, not uplifting. Is it possible that the primitive open forest could be restored, at least on a local scale? And if so, how? We cannot offer an answer. But we are posing a question to which there should be an answer of immense concern to the National Park Service.

The scarcity of bighorn sheep in the Sierra Nevada represents another type of management problem. Though they have been effectively protected for nearly half a century, there are fewer than 400 bighorns in the Sierra. Two-thirds of them are found in summer along the crest which lies within the eastern border of Sequoia and Kings Canyon National Parks. Obviously, there is some shortcoming of habitat that precludes further increase in the population. The high country is still recovering slowly from the devastation of early domestic sheep grazing so graphically described by John Muir. But the present limitation may not be in the high summer range at all but rather along the eastern slope of the Sierra where the bighorns winter on lands in the jurisdiction of the Forest Service. These areas are grazed in summer by domestic livestock and large numbers of mule deer, and it is possible that such competitive use is adversely affecting the bighorns. It would seem to us that the National Park Service might well take the lead in studying this problem and in formulating cooperative management plans with other agencies even though the management problem lies outside the park boundary. The goal, after all, is to restore the Sierra bighorn. If restoration is achieved in the Sequoia-Kings Canyon region, there might follow a program of re-introduction and restoration of bighorns in Yosemite and Lassen National Parks, and Lava Beds National Monument, within which areas this magnificent native animal is presently extinct.

We hope that these examples clarify what we mean by the goal of park management.

POLICIES OF PARK MANAGEMENT

The major policy change which we would recommend to the National Park Service is that it recognize the enormous complexity of ecologic communities and the diversity of management procedures required to preserve them. The traditional, simple formula of protection may be exactly what is needed to maintain such climax associations as arctic-alpine heath, the rain forests of Olympic peninsula, or the Joshua trees and saguaros of southwestern deserts. On the other hand, grasslands, savannas, aspen, and other successional shrub and tree associations may call for very different treatment. Reluctance to undertake biotic management can never lead to a realistic presentation of primitive America, much of which supported successional communities that were maintained by fires, floods, hurricanes, and other natural forces.

A second statement of policy that we would reiterate—and this one conforms with present Park Service standards—is that management be limited to native plants and animals. Exotics have intruded into nearly all of the parks but they need not be encouraged, even those that have interest or ecologic values of their own. Restoration of antelope in Jackson Hole, for example, should be done by managing native forage plants, not by planting crested wheat grass or plots of irrigated alfalfa. Gambel quail in a desert wash should be observed in the shade of a mesquite, not a tamarisk. A visitor who climbs a volcano in Hawaii ought to see mamane tees and silver-swords, not goats.

Carrying this point further, observable artificiality in any form must be minimized and obscured in every possible way. Wildlife should not be displayed in fenced enclosures; this is the function of a zoo, not a national park. In the same category is artificial feeding of wildlife. Fed bears become bums, and dangerous. Fed elk deplete natural ranges. Forage relationships in wild animals should be natural. Management may at times call for the use of the tractor, chain-saw, rifle, or flame-thrower but the signs and sounds of such activity should be hidden from visitors insofar as possible. In this regard, perhaps the most dangerous tool of all is the roadgrader. Although the American public demands automotive access to the parks, road systems must be rigidly prescribed as to extent and design. Roadless wilderness areas should be permanently zoned. The goal, we repeat, is to maintain or create the mood of wild America. We are speaking here of restoring wildlife to enhance this mood, but the whole effect can be lost if the parks are overdeveloped for motorized travel. If too many tourists crowd the roadways, then we should ration the tourists rather than expand the roadways.

Additionally in this connection, it seems incongruous that there should exist in the national parks mass recreation facilities such as golf courses, ski lifts, motorboat marinas, and other extraneous developments which completely contradict the management goal. We urge the National Park Service to reverse its policy of permitting these nonconforming uses, and to liquidate them as expeditiously as possible (painful as this will be to concessionaires). Above all other policies, the maintenance of naturalness should prevail.

Another major policy matter concerns the research which must form the basis for all management programs. The agency best fitted to study park management problems is the National Park Service itself. Much help and guidance can be obtained from ecologic research conducted by other agencies, but the objectives of park management are so different from those of state fish and game departments, the Forest Service, etc., as to demand highly skilled studies of a very specialized nature. Management without knowledge would be a dangerous policy indeed. Most of the research now conducted by the National Park Service is oriented largely to interpretive functions rather than to management. We urge the expansion of the research activity in the Service to prepare for future management and restoration programs. As models of the type of investigation that should be greatly accelerated we cite some of the recent studies of elk in Yellowstone and of bighorn sheep in Death Valley. Additionally, however, there are needed equally critical appraisals of ecologic relationships in various plant associations and of many lesser organisms such as azaleas, lupines, chipmunks, towhees, and other non-economic species.

In consonance with the above policy statements, it follows logically that every phase of management itself be under the full jurisdiction of biologically trained personnel of the Park Service. This applies not only to habitat manipulation but to all facets of regulating animal populations. Reducing the numbers of elk in Yellowstone or of goats on Haleakala Crater is part of an overall scheme to preserve or restore a natural biotic scene. The purpose is single-minded. We cannot endorse the view that responsibility for removing excess game animals be shared with state fish and game departments whose primary interest would be to capitalize on the recreational value of the public hunting that could thus be supplied. Such a proposal imputes a multiple use concept of park management which was never intended, which is not legally permitted, nor for which we can find any impelling justification today.

Purely from the standpoint of how best to achieve the goal of park management, as here defined, unilateral administration directed to a single objective is obviously superior to divided responsibility in which secondary goals, such as recreational hunting, are introduced. Additionally, uncontrolled public hunting might well operate in opposition to the goal, by removing roadside animals and frightening the survivors, to the end that public viewing of wildlife would be materially impaired. In one national park, namely Grand Teton, public hunting was specified by Congress as the method to be used in controlling elk. Extended trial suggests this to be an awkward administrative tool at best.

Since this whole matter is of particular current interest it will be elaborated in a subsequent section on methods.

METHODS OF HABITAT MANAGEMENT

It is obviously impossible to mention in this brief report all the possible techniques that might be used by the National Park Service in manipulating plant and animal populations. We can, however, single out a few examples. In so doing, it should be kept in mind that the total area of any one park, or of the parks collectively, that may be managed intensively is a very modest part indeed. This is so for two reasons. First, critical areas which may determine animal abundance are often a small fraction of total range. One deer study on the west slope of the Sierra Nevada, for example, showed that important winter range, which could be manipulated to support the deer, constituted less than two per cent of the year-long herd range. Roadside areas that might be managed to display a more varied and natural flora and fauna can be rather narrow strips. Intensive management, in short, need not be extensive to be effective. Secondly, manipulation of vegetation is often exorbitantly expensive. Especially will this be true when the objective is to manage ''invisibly''—that is, to conceal the signs of management. Controlled burning is the only method that may have extensive application.

The first step in park management is historical research, to ascertain as accurately as possible what plants and animals and biotic associations existed originally in each locality. Much of this has been done already.

A second step should be ecologic research on plant-animal relationships leading to formulation of a management hypothesis.

Next should come small scale experimentation to test the hypothesis in practice. Experimental plots can be situated out of sight of roads and visitor centers.

Lastly, application of tested management methods can be undertaken on critical areas.

By this process of study and pre-testing, mistakes can be minimized. Likewise, public groups vitally interested in park management can be shown the results of research and testing before general application, thereby eliminating possible misunderstanding and friction.

Some management methods now in use by the National Park Service seem to us potentially dangerous. For example, we wish to raise a serious question about the mass application of insecticides in the control of forest insects. Such application may (or may not) be justified in commercial timber stands, but in a national park the ecologic impact can have unanticipated effects on the biotic community that might defeat the overall management objective. It would seem wise to curtail this activity, at least until research and small-scale testing have been conducted.

Of the various methods of manipulating vegetation, the controlled use of fire is the most "natural" and much the cheapest and easiest to apply. Unfortunately, however, forest and chaparral areas that have been completely protected from fire for long periods may require careful advance treatment before even the first experimental blaze is set. Trees and mature brush may have to be cut, piled, and burned before a creeping ground fire can be risked. Once fuel is reduced, periodic burning can be conducted safely and at low expense. On the other hand, some situations may call for a hot burn. On Isle Royale, moose range is created by periodic holocausts that open the forest canopy. Maintenance of the moose population is surely one goal of management on Isle Royale.

Other situations may call for the use of the bulldozer, the disc harrow, or the spring-tooth harrow to initiate desirable changes in plant succession. Buffalo wallows on the American prairie were the propagation sites of a host of native flowers and forbs that fed the antelope and the prairie chicken. In the absence of the great herds, wallows can be simulated.

Artificial reintroduction of rare native plants is often feasible. Overgrazing in years past led to local extermination of many delicate perennials such as some of the orchids. Where these are not reappearing naturally they can be transplanted or cultured in a nursery. A native plant, however small and inconspicuous, is as much a part of the biota as a redwood tree or a forage species for elk.

In essence, we are calling for a set of ecologic skills unknown in this country today. Americans have shown a great capacity for de-grading and fragmenting native biotas. So far we have not exercised much imagination or ingenuity in rebuilding damaged biotas. It will not be done by passive protection alone.

CONTROL OF ANIMAL POPULATIONS

Good park management requires that ungulate populations be reduced to the level that the range will carry in good health and without impairment to the soil, the vegetation, or to habitats of other animals. This problem is world-wide in scope, and includes non-park as well as park lands. Balance may be achieved in several ways.

(a) *Natural predation.*—Insofar as possible, control through natural predation should be encouraged. Predators are now protected in the parks of the United States, although unfortunately they were not in the early years and the wolf, grizzly bear, and mountain lion became extinct in many of the national parks. Even today populations of large predators, where they still occur in the parks, are kept below optimal level by programs of predator control applied outside the park boundaries. Although the National Park Service has attempted to negotiate with control agencies of federal and local governments for the maintenance of buffer zones around the parks where predators are not subject to systematic control, these negotiations have been only partially successful. The effort to protect large predators in and around the parks should be greatly intensified. At the same time, it must be recognized that predation alone can seldom be relied upon to control ungulate numbers, particularly the larger species such as bison, moose, elk, and deer; additional artificial controls frequently are called for.

(b) *Trapping and transplanting.*—Traditionally in the past the National Park Service has attempted to dispose of excess ungulates by trapping and transplanting. Since 1892, for example, Yellowstone National Park alone has supplied 10,478 elk for restocking purposes. Many of the elk ranges in the western United States have been restocked from this source. Thousands of deer and lesser numbers of antelope, bighorns, mountain goats, and bison also have been moved from the parks. This program is fully justified so long as breeding stocks are needed. However, most big game ranges of the United States are essentially filled to carrying capacity, and the cost of a continuing program of trapping and transplanting cannot be sustained solely on the basis of controlling populations within the parks. Trapping and handling of a big game animal usually costs $50 to $150 and in some situations much more. Since annual surpluses will be produced indefinitely into the future, it is patently impossible to look upon trapping as a practical plan of disposal.

(c) *Shooting excess animals that migrate outside the parks.*—Many park herds are migratory and can be controlled by public hunting outside the park boundaries. Especially is this true in mountain parks which usually consist largely of summer game range with relatively little winter range. Effective application of this form of control frequently calls for special regulations, since migration usually occurs after normal hunting dates. Most of the western states have cooperated with the National Park Service in scheduling late hunts for the specific purpose of reducing park game herds, and in fact most excess game produced in the parks is so utilized. This is by far the best and the most widely applied method of controlling park populations of ungulates. The only danger is that migratory habits may be eliminated from a herd by differential removal, which would favor survival of non-migratory individuals. With care to preserve, not eliminate, migratory traditions, this plan of control will continue to be the major form of herd regulation in national parks.

(d) *Control by shooting within the parks.*—Where other methods of control are inapplicable or impractical, excess park ungulates must be removed by killing. As stated above in the discussion of park policy, it is the unanimous recommendation of this Board that such shooting be donducted by competent personnel, under the sole jurisdiction of the National Park Service, and for the sole purpose of animal removal, not recreational hunting. If the magnitude of a given removal program requires the services of additional shooters beyond regular Park Service personnel, the selection, employment, training, deputization, and supervision of such additional personnel should be entirely the responsibility of the National Park Service. Only in this manner can the primary goal of wildlife management in the parks be realized. A limited number of expert riflemen, properly equipped and working under centralized direction, can selectively cull a herd with a minimum of disturbance to the surviving animals or to the environment. General public hunting by comparison is often non-selective and grossly disturbing.

Moreover, the numbers of game animals that must be removed annually from the parks by shooting is so small in relation to normally hunted populations outside the parks as to constitute a minor contribution to the public bag, even if it were so utilized. All of these points can be illustrated in the example of the north Yellowstone elk population which has been a focal point of argument about possible public hunting in national parks.

(e) *The case of Yellowstone.*—Elk summer in all parts of Yellowstone Park and migrate out in nearly all directions, where they are subject to hunting on adjoining public and private lands. One herd, the so-callel Northern Elk Herd, moves only to the vicinity of the park border where it may winter largely inside or outside the park, depending on the severity of the winter. This herd was estimated to number 35,000 animals in 1914 which was far in excess of the carrying capacity of the range. Following a massive die-off in 1919-20 the herd has steadily decreased. Over a period of 27 years, the National Park Service removed 8,825 animals by shooting and 5,765 by live-trapping; concurrently, hunters took 40,745 elk from this herd outside the park. Yet the range continued to deteriorate. In the winter of 1961-62 there were approximately 10,000 elk in the herd and carrying capacity of the winter range was estimated at 5,000. So the National Park Service at last undertook a definitive reduction program, killing 4,283 elk by shooting, which along with 850 animals removed in other ways (hunting outside the park, trapping, winter kill) brought the herd down to 5,725 as censused from helicopter. The carcasses of the elk were carefully processed and distributed to Indian communities throughout Montana and Wyoming; so they were well used. The point at issue is whether this same reduction could or should have been accomplished by public hunting.

In autumn during normal hunting season the elk are widely scattered through rough inaccessible mountains in the park. Comparable areas, well stocked with elk, are heavily hunted in adjoining national forests. Applying the kill statistics from the forests to the park, a kill of 200-400 elk might be achieved if most of the available pack stock in the area were used to transport hunters within the park. Autumn hunting could not have accomplished the necessary reduction.

In mid-winter when deep snow and bitter cold forced the elk into lower country along the north border of the park, the National Park Service undertook its reduction program. With snow vehicles, trucks, and helicopters they accomplished the unpleasant job in temperatures that went as low as —40° F. Public hunting was out of the question. Thus, in the case most bitterly argued in the press and in legislative halls, reduction of the herd by recreational hunting would have been a practical impossibility, even if it had been in full conformance with park management objectives.

From now on, the annual removal from this herd may be in the neighborhood of 1,000 to 1,800 head. By January 31, 1963, removals had totalled 1,300 (300 shot outside the park by hunters, 600 trapped and shipped, and 406 killed by park rangers). Continued special hunts in Montana and other forms of removal will yield the desired reduction by spring. The required yearly maintenance kill is not a large operation when one considers that approximately 100,000 head of big game are taken annually by hunters in Wyoming and Montana.

(f) *Game control in other parks.*—In 1961-62, excluding Yellowstone elk, there were approximately 870 native animals transplanted and 827 killed on 18 national parks and monuments. Additionally, about 2,500 feral goats, pigs and burros were removed from three areas. Animal control in the park system as a whole is still a small operation. It should be emphasized, however, that removal programs have not in the past been adequate to control ungulates in many of the parks. Future removals will have to be larger and in many cases repeated annually. Better management of wildlife habitat will naturally produce larger annual surpluses. But the scope of this phase of park operation will never be such as to constitute a large facet of management. On the whole, reductions will be small in relation to game harvests outside the parks. For example, from 50 to 200 deer a year are removed from a problem area in Sequoia National Park; the deer kill in California is 75,000 and should be much larger. In Rocky Mountain National Park 59 elk were removed in 1961-62 and the trim should perhaps be 100 per year in the future; Colorado kills over 10,000 elk per year in open hunting ranges. In part, this relates to the small area of the national park system, which constitutes only 3.9 per cent of the public domain; hunting ranges under the jurisdiction of the Forest Service and Bureau of Land Management make up approximately 70 per cent.

In summary, control of animal populations in the national parks would appear to us to be an integral part of park management, best handled by the National Park Service itself. In this manner excess ungulates have been controlled in the national parks of Canada since 1943, and the same principle is being applied in the parks of many African countries. Selection of personnel to do the shooting likewise is a function of the Park Service. In most small operations this would logically mean skilled rangers. In larger removal programs, there might be included additional personnel, selected from the general public, hired and deputized by the Service or otherwise engaged, but with a view to accomplishing a task, under strict supervision and solely for the protection of park values. Examples of some potentially large removal programs where expanded crews may be needed are mule deer populations on plateaus fringing Dinosaur National Monument and Zion National Park (west side), and white-tailed deer in Acadia National Park.

WILDLIFE MANAGEMENT ON NATIONAL RECREATION AREAS

By precedent and logic, the management of wildlife resources on the national recreation areas can be viewed in a very different light than in the park system proper. National recreation areas are by definition multiple use in character as regards allowable types of recreation. Wildlife management can be incorporated into the operational plans of these areas with public hunting as one objective. Obviously, hunting must be regulated in time and place to minimize conflict with other uses, but it would be a mistake for the National Park Service to be unduly restrictive of legitimate hunting in these areas. Most of the existing national recreation areas are federal holdings surrounding large water impoundments; there is little potentiality for hunting. Three national seashore recreational areas on the East Coast (Hatteras, Cape Cod, and Padre Island) offer limited waterfowl shooting. But some of the new areas being acquired or proposed for acquisition will offer substantial hunting opportunity for a variety of game species. This opportunity should be developed with skill, imagination, and (we would hopefully suggest) with enthusiasm.

On these areas as elsewhere, the key to wildlife abundance is a favorable habitat. The skills and techniques of habitat manipulation applicable to parks are equally applicable on the recreation areas. The regulation of hunting, on such areas as are deemed appropriate to open for such use, should be in accord with prevailing state regulations.

NEW NATIONAL PARKS

A number of new national parks are under consideration. One of the critical issues in the establishment of new parks will be the manner in which the wildlife resources are to be handled. It is our recommendation that the basic objectives and operating procedures of new parks be identical with those of established parks. It would seem awkward indeed to operate a national park system under two sets of ground rules. On the other hand, portions of several proposed parks are so firmly established as traditional hunting grounds that impending closure of hunting may preclude public acceptance of park status. In such cases it may be necessary to designate core areas as national parks in every sense of the word, establishing protective buffer zones in the form of national recreation areas where hunting is permitted. Perhaps only through compromises of this sort will the park system be rounded out.

SUMMARY

The goal of managing the national parks and monuments should be to preserve, or where necessary to recreate, the ecologic scene as viewed by the first European visitors. As part of this scene, native species of wild animals should be present in maximum variety and reasonable abundance. Protection alone, which has been the core of Park Service wildlife policy, is not adequate to achieve this goal. Habitat manipulation is helpful and often essential to restore or maintain animal numbers. Likewise, populations of the animals themselves must sometimes be regulated to prevent habitat damage; this is especially true of ungulates.

Active management aimed at restoration of natural communities of plants and animals demands skills and knowledge not now in existence. A greatly expanded research program, oriented to management needs, must be developed within the National Park Service itself. Both research and the application of management methods should be in the hands of skilled park personnel.

Insofar as possible, animal populations should be regulated by predation and other natural means. However, predation cannot be relied upon to control the populations of larger ungulates, which sometimes must be reduced artificially.

Most ungulate populations within the parks migrate seasonally outside the park boundaries where excess numbers can be removed by public hunting. In such circumstances the National Park Service should work closely with state fish and game departments and other interested agencies in conducting the research required for management and in devising cooperative management programs.

Excess game that does not leave a park must be removed. Traping and transplanting has not proven to be a practical method of control, though it is an appropriate source of breeding stock as needed elsewhere.

Direct removal by killing is the most economical and effective way of regulating ungulates within a park. Game removal by shooting should be conducted under the complete jurisdiction of qualified park personnel and solely for the purpose of reducing animals to preserve park values. Recreational hunting is an inappropriate and non-conforming use of the national parks and monuments.

Most game reduction programs can best be accomplished by regular park employees. But as removal programs increase in size and scope, as well may happen under better wildlife management, the National Park Service may find it advantageous to employ or otherwise engage additional shooters from the general public. No objection to this procedure is foreseen so long as the selection, training, and supervision of shooting crews is under rigid control of the Service and the culling operation is made to conform to primary park goals.

Recreational hunting is a valid and potentially important use of national recreation areas, which are also under jurisdiction of the National Park Service. Full development of hunting opportunities on these areas should be provided by the Service.

(The report was presented to the Honorable John A. Carver, Jr., Assistant Secretary of the Department of the Interior, who accepted the report on behalf of the Secretary of the Interior. Secretary Udall was forced to cancel his personal appearance because of a last-minute change in plans.)

The following letter was read by Mr. Carver.

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
Washington 25, D. C.

March 1, 1963

Dear Dr. Leopold:

Last year I called upon you as a private citizen to help the Department upon one of its most difficult problems, the management of wildlife. You and the rest of the special committee completed the first phase of your assignment when you submitted your report on wildlife management in national parks.

I like the quality of the report and the broad base you have used to develop your observations and recommendations. It is a constructive report that will serve as a guide to this Department and to the National Park Service through the years ahead.

You have stated the fact well that protection alone cannot continue to preserve the wildlife and its environment. The effects of man inside the parks and beyond park boundaries cannot be dismissed. You ask us to face up to the realities of the situation. One of your recommendations is that research must be conducted at a much greater rate than in the past to guide management. I am in complete agreement with you on the need for more research. This must be followed by forthright management. I think, too, that we must make a greater effort to coordinate national park wildlife management with that of the surrounding sates, but I agree with you that the National Park Service cannot abdicate its responsibilities nor delegate them to others.

As new national recreation areas are created by Congress, opportunities will increase for the development of public hunting throughout our land. I am pleased that you noted this. When the Land and Water Conservation Bill is enacted into law, certain types of lands will be purchased and developed by the Federal, State, and local governments for outdoor recreation, often including hunting. The total effect will be to enhance hunting opportunities.

President Kennedy's message on conservation to Congress gave us a new definition of conservation for the 1960's, that included the whole spectrum of resources with a cautionary note that we should not neglect human resources. Our conservation efforts must include the conservation of our natural, cultural and human resources for the betterment of society as a whole. National parks, with their wildlife resources as intact as we can manage them, are for people to enjoy. Your study will help us to sustain and, if necessary, to re-establish this situation.

On behalf of the Department, I wish to commend you and your committee for this act of public service. I know that every member of the committee is a busy man and, as such in great demand.

Sincerely yours,
Signed—Stewart L. Udall
Secretary of the Interior

Dr. A. Starker Leopold
Museum of Vertebrate Zoology
University of California
Berkeley 4, California

DISCUSSION

MR. TRUEMAN: Are there any questions of Professor Leopold or Mr. Carver?

MR. GIL HUNTER [Colorado]: Honorable Secretary, Dr. Leopold, Mr. Chairman: I think the report was well presented. However, I don't agree with it at all.

We have just tried to whip a situation around the boundary of the National Park, and we have done quite well. In fact, we have killed more elk than I ever figured we would on the border of the Park. The National Park Service is dumping, so to speak, the problem on the state administrator where under good control management they could handle the problem in the Park.

Now, I do not advocate any wide-open hunting in the parks. It would have to be limited, I appreciate that. But most parks are so located that you can control hunting. If the average State could control their hunters going into the National Park, we would have no trouble at all.

That is about the only thing that I say. I am a States righter, as you can well appreciate, and I believe we should have a great deal more to say about the management of natural resources in the Parks.

DR. LEOPOLD: Gil, I would answer you in part, at least. Certainly where a wildlife resource is inside the Park part of the time and outside the Park at other times, there is an obligation both on the part of the National Park Service and the State and Federal agencies involved for cooperative management. I must say that your State of Colorado is doing an outstandingly good job in this regard. We also encountered some other excellent examples where both the research and the cooperative management are being worked out jointly on the part of the Park Service and other agencies. I would say specifically that the management plan for the Gallatin elk herd in the northwest corner of Yellowstone National Park is one of the best that we saw in terms of research and cooperative endeavors that went into that plan.

Surely it is worth undertaking to attempt to resolve these problems outside the Park and retain the Parks for their primary purpose which, I think you will admit, is not public hunting. If it can be done with this type of cooperative program, and we think it can, this is far preferable to overlapping non-conforming uses to solve a specific problem more easily by public hunting within a Park.

I still think that the cooperative program, both research and management, is worth the effort because it is to the interest of the Park Service, of the state game officials, and the non-hunting American public, to whom we have some very real obligations.

GENERAL SESSION

Wednesday Afternoon—March 6

Chairman: RUDOLPH K. FROKER
Dean, College of Agriculture, University of Wisconsin, Madison, Wisconsin

Vice-Chairman: G. W. I. CREIGHTON
Deputy Minister, Nova Scotia Department of Lands and Forests, Halifax, Nova Scotia

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CONSERVATION'S WORLD-WIDE CHALLENGE

INTRODUCTORY REMARKS OF THE CHAIRMAN

RUDOLPH K. FROKER

Our charge this afternoon is to discuss the world-wide challenge of conservation. To me, the subject of conservation is in itself very broad. To assess its world-wide implications adds dimensions of breadth and scope which cannot help but challenge the speakers as well as all others in wildlife management and conservation. Fortunately, our distinguished panelists bring a broad perspective, extensive knowledge and much wisdom.

I searched my own record to try to find some qualification for my part in a Wildlife Management Institute program. I like the outdoors, the woods, the streams and the lakes. Sometimes I do a little fishing but usually with not much success. Surely, these are not sufficient reasons for my being selected as your chairman. Could it be that your program committee has attached some special significance to the fact that for the past 15 years I have been a dean in one of our modern universities where there is supposed to be considerable wild life?

This conference in other years has had an international flavor as it does today, and it has been concerned with conservation problems throughout the world. Thus, for example, the status of the European chamois, the conservation of small birds in France, grazing in Hawaiian national parks, game-bird rearing in England are a few of the subjects discussed at previous meetings and recorded in the published transactions. Recent conferences have given much attention to African game problems. In addition, numerous papers on conservation matters have been presented by scientists from our hemispheric partners in these meetings, namely Canada and Mexico.

My own interest in wildlife management and conservation deepens as I think of the shrinking habitat for wildlife, our rapidly expanding population, the modern equipment, devises and skills for exploiting wild animals, fish and birds. I know too that the way we manage our farms and forests, the way we waste or conserve our soil, the extent to which we protect or pollute our streams and lakes, will in turn have a tremendous impact on the wildlife and recreational resources of this country. We are a rich country with abundant resources but we are too poor to afford waste and mismanagement.

In the United States we have achieved a measure of success on conservation programs. Regional and national groups continue to make progress. Success, however, is neither certain nor adequate, yet, the results have been encouraging. Witness the efforts of the Soil Conservation Service to safeguard our soil, state and federal refuge systems for waterfowl, antipollution and lake and stream improvement programs, and the educational activities of state and federal extension units.

In North America, our joint conservation efforts with Canada have been extensive, cordial, fruitful and mutually beneficial. Our joint efforts with Mexico have been no less pleasant and productive although not as extensive. We are proud of these cooperative undertakings.

In the broader international sphere of conservation activity, however, we are just beginning to define the areas in which we can and should accept the challenges of world-wide problems. To stand idly by, smug in our limited success would be naive, or callously indifferent to those problems which arise in a world of rapidly-expanding population on a steadily-shrinking resource base. This conference is testimony of your interest and that you do not intend to be passive in your attitude toward this immense problem.

Our lead-off speaker this afternoon must be admired and respected for tackling one of the toughest jobs in government service. To the best of my knowledge, no man in recent years has taken the position of Secretary of Agriculture for its popularity or glamour and certainly not while we have been plagued with farm surpluses.

This apparently was no deterrent to the current Secretary since, as in most everything else he has done, he has been faced with challenging and difficult situations.

Orville Freeman was named Secretary of Agriculture in 1961 after serving three terms as Governor of Minnesota. His six years as governor of one of the great outdoor recreational states of the nation and his two years as our country's chief agricultural executive give him a wealth of background for his address to us today.

Born in Minneapolis in 1918, he spent his summers as a youth on the family farm near Zumbrota, Minnesota. He attended the University of Minnesota, and graduated in 1940 with a B.A. degree. He was a quarterback on the Golden Gopher squad in the late 1930's. (He directed big things even in those days.) Mr. Freeman entered the Minessota University Law School shortly after obtaining his bachelor degree but interrupted his education to serve in the United States Marines. He was seriously wounded on Bougainville but upon recovery he continued in active duty in Washington D. C. where he helped establish the Marine Corps Rehabilitation program.

Later while completing his law degree at the University and after graduation, Freeman was assistant to the mayor of Minneapolis. From 1946 to 1949 he was chairman of the Minneapolis Civil Service Commission.

Our speaker was elected Governor of Minnesota in 1954, after being a candidate for state attorney general in 1950 and for governor in 1952. He was re-elected Governor in 1956 and 1958.

President Kennedy chose Secretary Freeman to direct one of the nation's most complex departments in 1961 and it is from that position he comes to us today.

I am happy to present Secretary Orville Freeman.

CONSERVATION FOR WORLD PEACE

THE HONORABLE ORVILLE L. FREEMAN
Secretary of Agriculture, Washington, D. C.

Almost a year ago at the White House Conference on Conservation I outlined a new proposal to expand the role of conservation . . . to give it new dimension . . . and to use this new dimension to help unravel one of the great paradoxes of our modern age.

The proposal would apply more broadly the concept of multiple-use of resources to private lands. By doing so a bright ray of hope is focused on the paradox of an *overabundance of food* and a *growing shortage of outdoor recreation.*

I believe the answer to one can be found in the solution of the other —thus actually applying a basic principle of conservation.

What I described last May were general proposals contained in legislation then pending before the Congress. These proposals became the Rural Areas Development sections of the Food and Agriculture Act of 1962. The support we received from the groups represented at this conference was instrumental in the enactment of these proposals.

I am grateful for that support . . . and I am here today to describe in specific terms how we are moving with your help to give form to this new dimension of conservation.

I also want to challenge you . . . to call forth your energy and your experience . . . your support . . . for the difficult and exciting task ahead as we begin to translate new ideas and new programs into progress. In a very real sense we are exploring an uncharted frontier in this program. There is little to guide us other than the knowledge of what needs to be done and the philosophy of conservation.

Thus we seek to shape the great forces of change sweeping rural America . . . helping the direct these forces into channels that benefit all of us—farmer, rural nonfarmer and city dweller alike.

If that sounds like trying to harness a whirlwind . . . then so be it.

Lets take a look for a moment at some of the forces in this whirlwind.

One is the simple fact that American cropland is producing more food and fiber than we can consume, export for dollars, or use effectively in the Food for Peace program. Such a flat statement may shock you, but it's true. The implications that flow from this situation are complex and far reaching.

For one thing, despite the immense productivity of the farmer—who represents less than 8 per cent of the nation's work force—he does not share equally in the prosperity of this nation. He feeds us better and at less cost than ever before, but his annual income is less than 60 per cent, on the average, of nonfarm income. This fact has an important bearing on conservation decisions.

Practical and realistic, as well as idealistic in their love of the land, farmers must take into account the economic facts of life in making conservation decisions. An agriculture harassed by substandard levels of income—with all that this implies in terms of priorities of outlay—is less likely to be willing, or able, to use the land as it should be used.

What does this mean to you . . . to the urban dweller . . . to this **nation?**

Consider this:

1. Nearly three-fourths of all the land in the 48 contiguous States is in private ownership.
2. More than three-fifths of all land in the 50 States is privately owned.
3. This land, with the National Forests, is the great gathering place and reservoir of most of the fresh water for farm, city, industry, fish and wildlife, and recreation.
4. Privately owned land produces 80 per cent of the game taken by hunting, and has 85 per cent of the wildlife habitat economically feasible of improvement.

Here, on these rural lands near the crowded millions in our cities, convenient and easily accessible, in space for outdoor recreation, and the water, fish, game, wild creatures and woodlands to make outdoor recreation truly meaningful.

The decisions on how these resources are used and conserved belong to the farmer—to those who own and manage the land, its waters, and related resources. The final decision is theirs . . . this is the way of the democracy.

If the farmer must decide under the pressure of inadequate income, then those decisions will relate more to the immediate problems of his economic survival than to the long-range problems of an urban nation increasingly hungry for scarce recreational resources . . . and for a water supply which is becoming increasingly inadequate.

Agricultural policy and conservation policy for privately owned land must be compatible. They must merge into programs that give fair consideration to farm income and farm levels of living, and that protect, improve and develop natural resources.

And they must go further than this. They must meet the needs of both the farmer and nonfarmer.

This brings me to the second force of this great whirlwind of change we have set out to harness. Outdoor recreation is one of the great unmet needs of the nation today. The Outdoor Recreation Review Commission reports that Americans are seeking the outdoors as never before. It estimates that by the year 2000 the demand for recreation should triple.

The Department has already felt the impact of this urban created demand. Recreation visits to the National Forests have increased 340 per cent in the past decade. Last year there were 113 million recreational visits. We predict that there will be over 300 million visits by 1980 and more than 635 million by the start of the 21st century.

There is no question but that publicly provided recreation facilities will continue to grow in number and importance. In the past 5 years, the Forest Service has built camping and picnic facilities for 100,000 persons . . . and we will need 283,000 more in 10 years. Last year, 150 miles of sportsman access roads and trails were built by the Forest Service. The Accelerated Public Works program also helps. Some 3,500 new family camp and picnic units were constructed and 1,200 were rehabilitated in the first two months of its operation.

Under the Mission 66 program, the National Park Service has continued to expand recreational facilities in the National Parks, and is adding new areas to meet a burgeoning demand. The Departments of Agriculture and Interior recently buried old antagonisms to work together to develop National Recreation areas. Currently, both Departments are jointly planning two recreation areas—the Shasta-Whiskytown area in California and the Flaming Gorge area in Utah.

Even these developments, however, will not be enough. Many public areas are too far distant from metropolitan centers to provide for an afternoon outing . . . and even the projected growth cannot keep pace with booming demand.

But with the expansion of recreational opportunities on privately owned land—the farms, ranches and woodlands that make up 75 per cent of our land area—the demand can be met. This can be done only by willing rural landowners who are encouraged by urban dwellers who have so much to gain.

This, to a limited degree, outlines the need which propels us into a new frontier of conservation.

But there are other needs which give urgency and importance to this new dimension of conservation.

We are all concerned that our water resources, once believed to be as inexhaustible as the air we breathe, are limited . . . and are being wasted at a prodigious rate. And even the air is being polluted to such an extent that it also has become a misused resource.

We know that the opportunities for non-farm jobs in rural areas are not adequate. Economists estimate that unemployment and underemployment in rural areas is now the equivalent of 4 million total unemployed . . . 1.4 million on farms and between 2 and 3 million among rural non-farm people.

The key point, I believe, is that we have made . . . and are making . . . far too limited use of the resources of rural areas. We have not practiced conservation in its best sense . . . the wise use of our natural resources to meet the needs of people.

We have too much land producing crops we cannot effectively use . . . and too few acres producing the recreation we need. By 1980, we estimate that we can meet all needs for food and fiber of a growing population at home and abroad with 50 million fewer acres than we presently have available for cropping.

Not one of these 50 million acres need be classed as surplus.

They need not be idle. Idleness is not, and must never become, a part of conservation policy or of agricultural policy. Land and its renewable resources are for use . . . for use by people . . . for the benefit of people.

We guard, we conserve, we renew, and we develop resources . . . but we also use them.

Over the past 25 years, through our experience in the National Forests and our work with soil conservation districts, small watersheds and with farmer committees, we have evolved on public lands the concept of multiple-use of renewable resources.

We seek now to develop the techniques and procedures necessary to apply this concept into land use patterns on privately owned land in rural America.

Crop production, quality forage for cattle, and suitable habitat for game animals and birds occur on the same farm. Farm ponds stocked with fish . . . shrubs planted along fence rows mean better more diversified use of the land. Timber, water, wildlife habitat, upland game, forage, crops and recreation can be produced at the same time on the same land—on farms, ranches, and forests reaching from one end of this country to the other.

Water impounded to prevent floods can also provide habitat for game and fish, recreation for people, water for the community and the essential ingredient for industrial development.

Thus, at a time when the competition for land and water resources is intensifying, we are learning that land can serve a mulitplicity of uses without impairing its primary uses—whatever that may be.

How then do we propose to bring multiple-use to private lands? The Rural Areas Development program which was made possible by your support of legislation in 1962 points the way.

We consider RAD as a major effort to meet the challenge of imbalance in land use and population patterns as great change takes place in rural America. It blends new programs with present programs to focus all available resources to serve locally initiated and locally determined activities.

It seeks to fulfill several high-priority national goals.

1. To give direction, purpose and hope to rural America as it adjusts to rapd change.
2. To readjust rural land patterns, making more land available for the increasing needs of outdoor recreation and open spaces, while decreasing cropland acres.
3. To fully protect and develop the Nation's renewable resources of soil, water, forests, fish and wildlife, and open spaces.
4. To encourage more rapid rural industrialization and expansion of commercial enterprise in rural areas to provide new employment and other non-farm economic opportunities.
5. To eliminate the causes of rural poverty.
6. To strengthen the family farm pattern of agriculture, insuring an efficient and productive source of food and fiber in a way that increased efficiency does not bring less income to the producer.
7. To establish a reservoir of experience which the developing nations of the world—largely rural and agrarian—can adapt. It will serve as a constant reminder that democracy and the free enterprise system can solve the problems of rural poverty and provide the techniques for rapid economic growth.

These goals . . . as I see them . . . are set in the framework of two fundamental principles:

First, we must move economic opportunity into rural areas instead of forcing people out of the country by planned depression. Second, we must use land, and not idle it. Resources must be used in ways that conserve . . . and serve the real needs of all people, rural and urban.

Let me describe briefly five major avenues we propose to follow in mobilizing our resources in RAD—avenues made possible by legislation enacted into law last year. Three of them will be areas where this organization can give the most effective leadership in communities and counties throughout the nation.

First, we are approaching RAD through rural renewal projects—which are now authorized for rural areas for the first time in the Nation's history. We hope to make a start this year in up to four pilot projects, where we will be trying to learn the special techniques that will work in rural areas.

These pilot projects could well grow into the major effort by which local rural areas are aided by Federal and State Governments in eliminating rural slums and poverty. One thing is sure: If we are to erase the causes of rural poverty, we are going to have to think and act as big as we did 20 years ago when we began our big assault on similar problems in the city through urban renewal and slum clearance programs. At long last we can attack head on with new tools the deep-seated poverty of many sections of rural America.

Second, we are implementing RAD through a Land Use Conversion Program—with long-term agreements to help farmers substitute grass and trees . . . wildlife and recreational uses . . . on land that has been producing wheat, feed grains, or other crops now in surplus.

This program includes, in 41 pilot counties scattered around the country, cost-sharing, technical assistance, and transitional agreements to help compensate for temporary declines in farmer incomes.

Third, we are initiating new Resource Conservation and Development Projects—to provide financial and technical resources to assist land owners in adjusting their land use patterns. Here again we have land conversion and adjustment with the addition that a number of farmers can join together pooling their land in a common project.

For example, a pilot project could team a soil and water conservation district with a sportsman's club, the residents of a particular municipal subdivision, or a consumer's cooperative, to jointly develop outdoor recreation facilities. The city's people would get for their investment the use of outdoor recreation facilities, while rural land owners would tap a new source of income.

We hope to be able to launch about 10 such pilot projects in fiscal 1964, and to provide planning assistance to 10 or 15 other projects which could begin in fiscal 1965.

One project presently under consideration in South Dakota would provide three soil conservation districts with the solution to a critical silting problem in the large flood control projects along the Missouri river. The reservoir lakes are silting up rapidly, and small water impoundments along the short tributaries . . . plus the conversion of about 50,000 acres of cropland to grass . . . are needed to reduce the silting rate. The land, together with the additional water impoundments, can be used for recreation purposes and thus supplement the income of farmers and ranchers in the area while providing additional hunting and fishing opportunities to sportsmen.

Fourth, we are expanding the opportunities within the Watershed Protection program. Until last year, this program was directed at flood prevention and general watershed improvement, including fish and wildlife preservation. In 1962, the Congress expanded the purposes for which Federal assistance could be used to include recreation, industrial water and future municipal water supply.

We already have 25 tentative proposals from local organizations to increase the multiple purpose development of watershed projects. The rate of applications for assistance for such comprehensive projects has jumped 20 per cent in the last six months.

One such proposal under consideration is from the Baker River watershed in Grafton County, New Hampshire. The town of Plymouth has proposed that a flood prevention impoundment be expanded to provide a 105-acre lake which can be developed for public recreation purposes.

The town has developed plans for 25 camping units together with facilities for swimming, fishing and picnicking—all within two or three hours' drive from the densely populated areas of Southern New England.

The State Department of Resources and Economic Development has proposed that other reservoir sites in the watershed be expanded for recreation purposes. It will help provide campsites and other recreation facilities.

Its estimated these proposed new recreation areas will add over $120,000 a year to the income of residents in the rural counties involved.

Fifth, we are also preparing to help individual farmers to develop income producing recreation enterprises. The Farmers Home Administration is now authorized to provide Federal credit for on-farm or community recreation projects, fish farming or other activities which encourage new uses for cropland. The other agencies of the Department—and State agencies, as well—are gearing up to expand greatly their technical assistance in this area.

The first loan approved under this program was made to a group of 40 Colorado farmers to help finance the purchase of 15,000 acres of land—1,400 now producing crops—which will be developed for grazing, wildlife and recreation.

Habitat for small game animals will be improved as part of the project, including the improvement of a small stream which flows through the property.

There also are pending with FHA numerous on-farm recreation loans. One is from a small dairy farmer in New Jersey who wants to develop a 7-acre lake on his land and provide campsites and boating facilities for vacationers, and fishermen. We estimate such recreation facilities would add about $3,000 to his net income—about as much as he now earns from his farming operation.

The last three programs—Resource Conservation and Development projects, the expanded Watershed Protection Program and the FHA recreation loan program—are of special interest to you because they give meaningful support to the protection and preservation of wildlife.

But the whole RAD program—whether it is to encourage more rapid growth of rural industry or whether it provides better breeding sites and cover for quail and pheasant—is in harmony with the long-range goals of wildlife conservationists and sportsmen dedicated to the wise use of our great natural resources.

The support and leadership which I know you are capable of giving to this program is sorely needed. I am here today to speak frankly and directly to you to ask your help and leadership to get this program rolling.

The Rural Areas Development program is a conservation project of great magnitude, vital to the future prosperity of this nation. But it is the kind of program which can only succeed if local people want it to succeed . . . if they are so eager to see their community grow, to see new opportunities for themselves and their children that they step out and provide the local leadership without which RAD can only be a dream rather than an action program.

When we save a species of wildlife by protecting its habitat or by encouraging its propagation, we save more than a wild animal. In a sense, we save ourselves for we are saying—often instinctively—that civilization must permit all of God's creatures to live free of the threat of total destruction.

Gifford Pinchot, in *Breaking New Ground,* wrote "It is not easy for us moderns to realize our dependence on the earth. As civilization progresses, as cities grow, as the mechanical aids to human life increase, we are more and more removed from the raw materials of human existence, and we forget more easily that natural resources must be about us from our infancy or we cannot live at all."

Conservation in the most meaningful sense says that civilization must not commit man to live imprisoned in a megalopolis of steel, stone and asphalt.

In translating this concept into specific goals and specific actions, we move toward a dual objective. We can provide the urban dweller with open space and the enjoyment of the outdoors. And we can provide the person who desires to live in the small town or on the farm with equal opportunities for advancement as those of his brother in the city.

To paraphrase Aldo Leopold, the father of modern game management . . . we are embarking on a partnership enterprise to which each person contributes and from which each derives appropriate reards.

This is the purpose for which I work, and this is the purpose for which I ask your support and help.

TECHNICAL ASSISTANCE—NEEDS AND OPPORTUNITIES

HERBERT J. WATERS

Assistant Administrator for Material Resources, Agency for International Development, Department of State, Washington, D. C.

It is a real pleasure and privilege for me to appear here today as a representative of the Agency for International Development of the Department of State.

My assigned topic—Technical Assistance: Needs and Opportunities—is especially pleasing to me, for it provides me with a chance to speak to my fellow Americans on a subject that is closer to our own well-being than many of us realize.

Who can dispute the obvious need for assistance when more than one-third of the world's population lives at or below the bare subsistence level?

—and 75 per cent of the one billion people of the free world cannot read or write

—and less than 25 per cent of the school age children are in classrooms—and less than 2 per cent of them ever complete a secondary school education

—disease is rampant

—poverty is widespread and abysmal?

This is one of the major paradoxes of our time, for these conditions prevail simultaneously in a world where man's technological progress enables him to reach out for the stars.

Less spectacular than the ability to probe the moon—but of equal importance to mankind's development—is the fact that man has within his grasp the means and the knowledge to help to build productive and viable economies in the less developed nations right here on earth.

Some people argue that the United States is not justified in taking the lead or even sharing in what is now a multi-nation effort to meet mankind's rising aspirations.

I submit that there are two very cogent reasons why the American people are engaged in this tremendous undertaking. One may be termed humanitarian and the other, pure self-interest.

President Kennedy expressed the humanitarian aspects when he said,

"To those peoples in the huts and villages of half the globe struggling to break the bonds of mass misery, we pledge our best efforts to help them help themselves for whatever period is required . . . not because the communists may be doing it, not because we seek their votes, but because it is right. If a free society cannot help the many who are poor, it cannot save the few who are rich."

The second reason as I have said, is self-interest. Our own national security is involved.

Foreign aid helps to establish the basis for a stable and peaceful world community by promoting economic development, helping to maintain law and order, strengthening the governments in the new nations of the world, and at the same time preventing subversion and aggression. It is only in a climate of freedom and independence among the developing nations that our own nation can prosper and grow. Foreign aid gives beleaguered countries the additional strength needed to enable them to resist the communist threat.

But, whether for humanitarian purposes, or in the furtherance of self-interest, no nation can be secured for freedom or lifted out of poverty by foreign aid alone. Foreign aid must be wisely used so that it can act as a catalyst—a lever if you will—to accomplish results many times greater than the level of the investment itself.

And so, to encourage an increase in productivity in the developing nations, we provide technical assistance and know-how in almost every area of development, but most importantly, to the agricultural sector since most of the population lives in rural areas.

While no generalization is applicable to all developing nations, it is well to examine the conditions that prevail in most—conditions which prolong backwardness, hinder development and prolong despair.

The major segment of the productive capacity of the developing nations lies in agriculture.

In terms of agricultural skills and knowledge, the need is great indeed for the kind of basic facilities for education and training long since available throughout Europe and North America.

Modern scientific agricultural development is virtually unknown. The ratio of manpower to food yield is uneconomic—and this in the face of increasing population.

Many are one-crop exporters, exposed to the vagaries of nature and the uncertainties of fluctuating prices on the world market.

Much of the agriculture is of the subsistence type—with choice of crops based on utility in family consumption, rather than market value.

Agriculture is carried on in the traditional sense—with a low level of technology—one in which interest in innovation is lacking and in which there is no appreciation of the economic value of knowledge.

The rural population lives largely in an illiterate folk culture.

Progress toward social and economic development is necessarily impeded when people live in ignorance and must devote a high proportion of their time and effort to produce barely enough food to feed themselves. Walter Rostow in his book, "The Stages of Economic Growth" stated the proposition this way: ". . . the rate of increase in output of agriculture may set the limit within which . . . modernization proceeds."

The opportunity to provide the technical assistance needed for satisfying man's desires for a more favorable living standard in this increasingly populous world is at hand. It can be met by the increased use and application or adaptation of modern scientific methods and technology—methods which can transform the naturally poor agricultural environment into a more favorable one—one in which less time and effort need be expended by fewer people to raise more food.

Our experience here in the United States—in our own agricultural development—is an excellent example of our progress from an economy of scarcity to one of abundance.

In 1862, each American farmer supplied enough food for 4½ persons—including himself—little more than his own family. Today, 27 people—six times as many as 100 years ago—are supplied with food produced by a single farm worker. Fewer than 9 per cent of our labor force are engaged in agriculture today. Compare this with 70 or 80 per cent in many of the lesser developed countries.

This agricultural progress has not only provided us with an unprecedented abundance of food and fibre, but it has also contributed materially to economic growth in other segments of the economy. For, as agriculture advances, buying power increases and surplus labor is transferred to meet the expanding needs for industrial manpower.

To encourage such an increase in productivity in the developing areas of the Free World, the United States—ever since the Point Four Program—has provided technical assistance abroad in almost every area of economic, social and political endeavour.

For example, A. I. D. is contributing to a world-wide community water supply program which has as its primary emphasis the development of managerial skills—the administration of water systems. It is a program to develop technical competence rather than a program of pipes and valves.

We also emphasize training and development in the health field. For example, in Ecuador there are 3,000 private citizens, ranging from farmers to teachers, who have volunteered their services to assist in malaria eradication. They take blood samples, even administer drugs, help spray 450,000 dwellings every six months. They work without pay, but they take such pride in the local prestige they acquire that many display their simple instruction materials, supplied through the Alliance for Progress, on the walls for all to see—as professionals display their university diplomas.

The problem of decent housing is acute throughout the emerging nations. A.I.D.'s emphasis is on "self-help" housing, technical assistance, and the development of local credit institutions that will enable the average man to finance a decent home for his family.

In "self-help" housing neighbor helps neighbor. The cash outlay is limited to such items as nails and hinges.

In Santiago, Chile, a pioneer housing project has resulted in more than 650 livable homes built on the self-help principle. The Chilean government paid for the land, site development, utilities, building materials and administrative costs. A. I. D. paid for the constructing equipment, and provided technical assistance. The people who were to live in their own homes did the actual building.

The conquest of illiteracy—another social development technical assistance effort—is a challenge that truly tests man's imagination and skill. To respond to the need, A. I. D. has education programs in 45 nations, varying from the training of primary teachers to demonstrations in "do-it-yourself" school building.

In Latin America there has been an emphasis on filling the need for school buildings. This, too, has been a "self-help" enterprise. In Guatemala, where 72 per cent of the people can neither read nor write, the government and A. I. D. jointly launched a pilot program to construct more than 2,200 classrooms. It was thought that local residents, whose children would use the schools, would account for one-third of the construction cost. The fact is that these local residents have accounted for 44 per cent of the actual construction cost.

And in Colombia, the larger share of U.S. assistance for education is at the primary school level. It is based on the four year plan of the Ministry of Education to provide a minimum of five years schooling for every Colombian child. This plan looks to the construction of 22,000 primary classrooms, and the training of more than 16,000 primary teachers over the four year span at a cost of $98 million. The U.S. is strongly committed to this plan but the bulk of financing, about $60 million, is being carried by the Colombian government. If the goal of an assured primary education for every Colombian child is attained, this will have profound future implications for lifting the entire economic and social climate of the country.

Far from Latin America, in Turkey, A. I. D. has assisted in the literacy training of 150,000 Turkish soldiers and an additional 120,000 are expected to complete their training each year. This successful project has become a laboratory for developing a literacy program among Turkey's civilian population. To date, more than 3,000 primary school teachers have gained literacy teaching experience at the military centers. The goal is to reduce illiteracy in Turkey from 70 per cent to 30 per cent by 1975.

Where neglect and ignorance have allowed fertile lands to become semi-deserts, knowledge and technical assistance—properly applied—can make these arid lands productive once more.

Therefore, we are providing technical assistance in the field of agriculture—projects ranging from irrigation and agricultural drainage to flood control and terracing—from the introduction of scientific agricultural education to better seed production and fertilizer use.

For example, we have a contract with Mississippi State under which the university is assisting in the conduct of seminars—from Africa to Latin America—on the production and use of seeds. University technicians are also providing consultation services, teaching people how to produce, process and store seeds in order to increase agricultural yield.

Agricultural experimentation in El Salvador has demonstrated that that country—a net importer of basic foods—can be made self sufficient in foodstuffs by the introduction of scientific farming methods and education of its agricultural workers. U.S. technical assistance has been provided to the National School of Agriculture in the fields of agronomy, agriculture and animal husbandry. Graduates of the school have become extension agents, co-op advisors and have found employment in both State and private enterprise agricultural activities.

In Taiwan, American technical assistance has helped raise farm productivity by 31 per cent in only a few years.

With U. S. technical assistance, over 200 varieties of vegetables have been tested in two Brazilian states. The better varieties are being distributed to farmer-seed producers who have planted them for the production of certified seed.

Combined research efforts of Brazilian and U. S. technicians have set the stage for the development of 400 million acres of sub-marginal land in Central Brazil. U. S. technically assisted soil and water conservation projects in these South American countries have led to the terracing, strip cropping, contour cultivation, irrigation and drainage of 100 thousand acres per year over the last three years.

In 1952, when India requested U. S. agricultural assistance, it was found that Indian crop yields were the lowest of any major country. Basic soil fertility data were either lacking or of little practical value to the farmer. Research institutions had neither the facilities or trained staff to conduct the kind of soil research so essential for determining the steps to be taken to increase crop yield.

With technical assistance projects, including soil testing and fertilizer production, storage and use, Indian crop yield has risen from 58 million to 78 million tons in ten years. I don't want to imply that the problem has been solved—but it is improving. Where there were no soil testing laboratories in India in 1952, by 1962 there were 24 servicing every one of its 15 states, staffed by soil chemists trained during the interim. There were practically no fertilizer field demonstrations, or trained personnel to conduct them in 1952. Since then, there have been more than 1 million field demonstrations and training courses conducted. Nitrogen fertilizer production has increased 15 fold and phosphate production is 10 times greater today than it was ten years ago.

Our agricultural abundance has contributed—and continues to contribute—substantially to such assistance.

For example, where large segments of the population are unemployed and underfed, workers usually are willing to accept food as partial payment of wages for work on high labor component projects such as land clearing, reforestation, and the construction of roads, bridges, schools, dams and irrigation and drainage ditches.

In Ethiopia, earth dams for reservoir or diversion purposes, ranging from 5 to 14 thousand cubic meter capacity, are being built by more than 2,500 workers under the food-for-wages program. On the average, it will take 100 men five months to build each of these dams, for we are contributing only the food and technical assistance, while the Ethiopians are providing the labor, the equipment—primitive at best—and whatever other resources are needed.

As you know, the fate of a nation's agriculture is seldom decided in the croplands alone. Forests store vast amounts of otherwise destructive rainfall, thereby increasing underground water supplies.

At the same time, forests shield crops, farm animals and wildlife against the drying winds of summer or the freezing gales of winter.

In trouble-torn Algeria, where, acting through the Church World Service rather than the government, we have provided wheat, nonfat dry milk, and edible oil in sufficient quantity to permit putting 18 thousand people to work on reforestation. They will set out 21 million trees on 28 sites, involving an estimated 53 thousand acres of land.

In Tunisia, over 200,000 workers have completed 3,500 projects ranging from well-digging to reforestation, and are now at work on other land-improvement and soil-conservation projects.

Another 200,000 are at work under a similar program in Morocco, where food is turning idle hands into constructive efforts in the building of access roads, urban rehabilitation, improving water resources and drainage, and erecting schools.

In Taiwan, some 5 thousand persons are engaged in similar food-financed activities. I stood on an eight-mile earthen dyke in Ilan, a province in Taiwan, as it was completed by rice farmers to save their crops from typhoon flooding. Through interpreters, these Chinese farmers told me that it couldn't have been done without our food being supplied to their families, thus freeing them to contribute their labor for a project that has preserved the entire area's farm productivity.

In India, some 20 thousand people have been restoring old irrigation systems to serve 40 thousand acres of land.

In Bahia, Brazil, road construction has been a major project under the food-for-wages program. A typical example is a 12 kilometer farm-to-market shortcut, which actually shortens by 30 kilometers the distance from the sisal producing area in Bahia to the regional marketing center.

We are helping to build cooperatives too, by substituting food and feed grants for dollars as "seed" capital. We intend to expand this program.

We are assisting in a CARE-sponsored hog production program in Hong Kong, involving the establishment of a cooperative Hog Producers' Association to which feed grains will be made available. Members of the Association will receive technical assistance in the production and marketing of hogs, and will be eligible to purchase feed and other supplies from the Association at reduced prices during a maximum period of three years. As they start to earn, prices of feed will be gradually increased toward commercial rates to build up capital reserves for the association, and to prepare the way for this group of producers to become a commercial market for U.S. feed grains in the future. Meanwhile, they will be depriving Red China of the Hong Kong pork market.

We are also ''grubstaking'' agricultural resettlement and colonization projects in support of land reform—in Africa, in the Middle East, and in Latin America. In Dahomey, a farm youth resettlement project, financed by food grants, has resulted in young farmers organizing cooperatives to clear new land areas for food production. Our food is enabling them to work—and to survive—until they are in full production. In Tanganyika, corn is being used to permit the establishment of 13 new cooperative agricultural settlements. In the Pindorama area of poverty-ridden northeast Brazil, food grants are providing farm families with an opportunity to resettle and acquire land of their own under a two-year program.

Underlying all these undertakings is the principle of "self-help." No matter how meager its resources, each cooperating country must contribute manpower and whatever leadership it possesses and must pay local costs. This places a challenge before the host country to do its part—to mobilize and provide its own resources—in a cooperative effort to achieve development. No nation can progress toward this goal unless its people see the need and have the will to overcome the obstacles standing between them and their economic and social betterment.

The need for technical assistance is widespread and insistent. For us, there can be only one possible course—and that is to seize the opportunity—to assist with our resources and skills and with our political and moral backing.

A revolution is taking place in the developing nations of the world. It is sparked by man's awakened desires for a better life and for a better chance at life's abundance—for himself and his children. We must do all we can to ensure that this is a *peaceful* revolution.

President Kennedy, at the first anniversary of the Alliance for Progress, clearly indicated the implications for us in the United States, when he said, "Those who make peaceful revolution impossible will make violent revolution inevitable.''

Whatever reasonable efforts we may make to help these struggling new nations help themselves—to demonstrate our concern and our commitment in their quest for viable economies and free, workable societies—are literally insignificant when compared to the expenditures we would have to make to preserve the security and integrity of our own country if large areas of the world should fall prey to communism, chaos and violence.

COOPERATION IN CONSERVATION

HAROLD A. VOGEL

North American Representative of the Food and Agriculture Organization of the United Nations, Washington, D. C.

Within a few weeks we will be celebrating the 20th anniversary of the first United Nations Conference on Food and Agriculture, held at Hot Springs, Virginia, in May 1943. This Conference, as you know, was called by President Roosevelt during one of the darkest periods of the war. Some questioned this action because it was feared that the Conference would detract from the immediate task of winning the war. But the President was convinced that "Winning the Peace" was just as important as winning the war. His aim was to reassure all peoples everywhere, including those who were conquered early in the war, that the Allied Nations, after defeating the enemy, would continue to cooperate actively with all the resources at their disposal to win the most basic of the Four Freedoms—freedom from want.

One of the important recommendations of the Hot Springs Conference, which was later made a part of the Constitution of FAO, concerns the promotion of national and international cooperation and action in the conservation and development of natural resources, including the promotion of improved management practices for agriculture, forestry, fisheries and related enterprises. I was pleased, therefore, when Dean Froker invited a representative of FAO to participate in your conference and to speak on the subject "Cooperation in Conservation."

Although I am stationed in the most highly developed region of the world, I have followed closely the evolution of FAO's work in the developing regions, particularly our programs of watershed management, planning the use of soil and water resources, grassland and forestry management, plant and animal production, wildlife management, ecological surveys, control of pests and diseases, fisheries development, shifting cultivation and many other activities that we include under our broad definition of "resource conservation." It is not my intention to describe FAO's work. Rather I would like to suggest some of the opportunities that exist today and in the years ahead for greater international and intergovernmental cooperation in conservation programs.

There are at least four powerful forces of the post-war era that are having a significant influence upon the nature and the degree of intergovernmental and international cooperation in resource conservation. Most of these forces can be used or drawn upon to stimulate and to facilitate even greater cooperation in the years ahead. To do so, however, we may need to adjust some of our thinking about the nature of conservation problems in many of the developing nations. We, too, may have to be prepared to work with and through new and unfamiliar administrative and institutional arrangements; and above all, we must maintain an attitude of patience with persistence in working with the governments and peoples of the developing nations.

For convenience we can identify these post-war forces as follows:

(1) the pride of nationalism;
(2) the urge for economic and social advancement;
(3) the wealth of experience gained in international consultation and action on technical and economic matters; and
(4) the world food and population situation.

NATIONALISM

The spirit of Nationalism stimulates citizen interest and action in a country's development efforts. This fact was impressed upon me during one of my visits to Egypt where I saw thousands of men and boys carrying rock and earth to build new levees along the Suez Canal. They had little equipment other than the bare hands. The going wage, I was told, was 40 cents a day plus bonuses for those who broke up the most rock or moved the most earth. Yet I was informed that this project compared favorably with similar operations elsewhere, even those having the advantages of the mechanical aids of the construction industry.

What released this enormous energy? The spirit of Nationalism. Egypt, like most underdeveloped countries today, is obsessed with a desire to reassert its pride in its own history and institutions and to recapture for itself something of the place it once held in the world. Like all Nationalism, Egypt's is a mixture of genuine patriotism and fierce resentment against the real or imagined oppression they feel they suffered in the past. While Egypt's leaders are denouncing more or less violently all alliances with foreigners, they are, along the Suez, the Nile and elsewhere, desperately trying to show the world that they can regain their position as one of the more highly developed nations of the world.

The pride of Nationalism can also be a powerful stimulant in various kinds of conservation activities, particularly those that involve the official sanction of governments and the general support of the people most directly concerned. The pride that newly independent people have in their freedom and in their natural inheritance has already been used effectively in organizing community development, in various types of local self-help projects, in conservation education and many similar efforts. The philosophy of the peasant, the rural leaders, and even the public officials of most of the developing countries, has been well expressed by a Nigerian Chief in these words: "I conceive that our lands belong to a vast family, of which many are dead, a few are living, and countless numbers are still unborn." A former United State Ambassador, in observing the pride of the newly independent nations in their natural resources, has said: "I have come to believe that the key to cooperation in Asia is a special reverent concept of land as the source of all wealth and goodness—a concept which seems to be shared in common by those who till the land."

THE URGE FOR DEVELOPMENT

One of the first official actions that a newly independent country usually takes is to apply for membership in the United Nations and in the several Specialized Agencies. Frequently a closely related action is to undertake the preparation of a national development plan. These actions reflect the interest these new countries have in achieving, as rapidly as possible, the highest possible level of economic self-sufficiency. It also reflects the realization by these less developed countries that poverty is not an act of Providence and that it can be remedied. They have come to know that through the adoption of scientific techniques, sound economic and social policies, and through adequate organization and utilization of their natural and human resources, many countries of the Western world have achieved a high level of economic prosperity and social welfare. This knowledge has made them aware of the challenge as well as the opportunities that lie ahead for them.

There is general consensus that the basic approach to an attack on the problem of poverty is to strive for balanced economic development. But such development itself is a complex matter. It embraces many questions relating to the application of scientific techniques, to economic arrangements and to adjustment of social institutions. They are all inter-related and cannot be isolated one from another. Yet the long-term answer to the problem of poverty must be sought in a generally expanding economy with the right balance between the various technical and economic sectors. This involves proper consideration of the basic resources, the wider use of scientific knowledge and methods, more purposeful reorientation of investment resources and the breaking of institutional bottlenecks that impede progress in many places.

While balanced development is essential, experience has shown that *agriculture is the key sector* in such development. Seventy to 90 per cent of the people of underdeveloped countries derive their livelihood from the land. Agriculture must not only provide adequate food supplies for a growing population, but, in addition, must provide a margin to start the process of capital formation. The initial impulse to increased production and improved well-being has to be generated in the rural sector.

Governments, in undertaking the planning of their national development, are obliged to draw heavily upon outside sources for advice and guidance in the many technical, economic and social fields. Some of this assistance is organized under joint planning missions involving the International Agencies, such as FAO. Bilateral programs such as AID, the Colombo Plan, and the several technical assistance programs sponsored by European countries, are also drawn upon heavily in the various stages of the planning process. These planning missions, if properly constituted, provide an excellent opportunity for promoting greater cooperation in resource conservation. There are also technical planning secretariats established in most of the countries to carry out the day-to-day surveys and related functions. They provide another channel through which sound technical knowledge of resource conservation can be brought to bear upon development planning operations. Most of the planning secretariats are composed of nationals of the country involved or are non-citizens directly employed by the governments concerned. Unfortunately governments are experiencing great difficulty in finding enough qualified personnel for their planning secretariats. In the years ahead we would hope that more and more trained and experienced persons from the more advanced countries would accept employment on the staffs of governments of the developing countries. Some governments, such as the Netherlands, Germany and Switzerland, have assigned young college graduates to FAO field missions as "Assistant Technicians," for the purpose of giving these young graduates an opportunity to gain field experience and to eventually find employment in the developing countries. This, in effect, involves a new technique for the exporting of surplus technical education and know-how—a practice that may become much more extensive in the years ahead. Most of the U. S. Peace Corps Volunteers assigned to FAO projects function in much the same way as these Assistant Technicians. We hope that many of them will find their services abroad so self-rewarding that they will take up a career in the international or foreign field after they have completed their tour of duty with the Peace Corps. Many of these volunteers would need to return to college and round out their technical training before they could qualify as an Expert in an international agency.

We should note that the type of planning undertaken in an underdeveloped country is usually quite different from that practiced here in North America. We here rely heavily upon the planning that is being done continuously by private industry and local communities. In most underdeveloped countries, however, the government must play a much more prominent role in the whole planning process. This is because a large majority of the people are still working under the handicaps of a subsistence economy. A subsistence economy does not generate, of its own accord, either the will or the human abilities necessary for dynamic economic change and growth. Neither can the private sectors in the limited market economies of many developing countries provide the necessary capital. They are much too small and inexperienced, and their influence is still much too weak to guide the economic system and move it to progressively higher levels of productivity.

In these circumstances, it is the governments which, for the present at least, have both the motivation and the ability to obtain the resources required for accelerated economic growth. Hence, effective planning by governments is an essential prerequisite for sound resource development in most new countries today. We must be prepared to work with and through such centralized planning structures, and at the same time find ways and means to bring the peasants, the village leaders, the nomadic tribes, and other local groups into the planning process.

A development plan must reflect the ideals and aspirations of the nation and the sacrifices that it must undertake in order to achieve its goals. Therefore it cannot be imposed from outside. But many countries need help in the techniques of planning and we are receiving more and more requests for assistance of this type. We are, therefore, taking steps to increase both the number and the effectiveness of our planning experts. We are constantly endeavoring to improve agricultural planning techniques, and are holding seminars for national planners. In all this work we lay particular emphasis on the fact that planning of the rural sector is not simply a matter of methodology, but also of intimate knowledge of the difficulties, the problems, the desires and the aspirations of the peoples of the areas being planned.

We also are giving more attention to the long-term problems and perspectives of rural development, both at the country level and at the regional level. Our study on the lower Ganges Basin of India and Pakistan was designed to determine what the long-term optimum pattern of land use might be in a region where the population growth makes it imperative to adopt the most intensive possible pattern of agriculural development. Our Mediterranean Development Project undertook to outline ways and means by which the land and water resources of the Mediterranean countries could be developed through well formulated medium-term development programs in such a way as to accelerate economic and social growth within the context of longer-term perspectives. This Mediterranean study, we believe, was a landmark in our efforts to establish an integrated regional approach to agricultural development, and the broad philosophy developed in this study is now being applied in pre-investment surveys of key development zones in six countries of the area.

EXPERIENCE IN INTERNATIONAL COOPERATION

The growing confidence of governments in their international organizations can be used to advantage in many ways to achieve greater intergovernmental cooperation. Since the last war the metropolitan powers have been subjected to enormous pressures to speed up the granting of self-government to their territories and possessions. As a result we find that, of the 104 governments that are now members of FAO, 41 have become independent countries since the last war.

These new countries in most instances were better prepared for the assumption of political control than they were for the nonpolitical responsibilities which every independent nation must assume. They are now finding that their development and welfare problems are in many ways more complex than they had anticipated. They are finding, too, that the internal forces which motivated strong desires for political freedom are becoming even more potent in creating the desire for better conditions of living. This creates more pressure for the speeding up of economic development schemes.

As these new countries embark upon their development programs they are faced with grave shortages of trained technicians and administrators, with serious deficiencies in the basic knowledge of their resources and with very limited supplies of capital. Where can they turn for help? The greatest sources, of course, are the more advanced nations. But these new countries often hesitate to draw on these sources for certain types of aid, particularly for advisers who would be closely associated with planning and policy-making functions of their governments.

The confidence that these countries have in FAO has made it advisable to devote a greater proportion of our technical resources to supplying them with such key advisers on agricultural, forestry, and fisheries policy and on program planning. Similarly, a greater proportion of FAO's aid is being directed toward the improvement of national administration and public services for rural development. These senior FAO advisers can be effective in encouraging governments to make better preparations for receiving technical assistance—to do a better job of planning their rural development, to create a better environment for acceptance and support of various types of bilateral aid, and to make more adequate provisions for experts and training activities in the various aspects of conservation.

Another function which international agencies like FAO can perform effectively involves the organization and servicing of *regional projects* which involve intergovernmental cooperation in the creation or utilization of some kind of regional institution. Experience has shown that governments of a region hesitate to join or to cooperate in certain types of regional programs, such as water control, animal disease programs, regional forestry institutes, etc., if such activities are not sponsored by a recognized international organization. Yet we know that certain kinds of technical assistance, including some training activities, can be handled more economically and most effectively on a regional basis. This has led some countries to suggest that FAO and the other Specialized Agencies should be placing much more emphasis on regional activities and that the bilateral agencies should be encouraged to cooperate more actively with international agencies in such work.

Another area where FAO has gained valuable experience and is achieving some success, is in the very difficult area of international consultation and action on production programs and commodity policy. For example, 42 nations have accepted the FAO Principles of Surplus Disposal which establish the "rules of fair trade" which protect friendly nations from unfair competition and unwise dumping practices in the marketing of surplus agricultural commodities. The formulation of these principles and rules were achieved only after intensive intergovernmental consultation through FAO.

Parallel services being rendered through regional forestry commissions, regional fisheries councils and special technical study groups serve to encourage cooperation and to eliminate or help reconcile artificial barriers or obstacles to resource conservation and development.

FAO has been equally successful in helping bring about coordinated national action through international consultations in various technical fields, resulting in such achievements as the Plant Protection Convention, the Desert Locust Control program, the International Rice Commission, regional rinderpest control operations and many others.

Each year FAO sponsors over 80 technical and intergovernmental meetings and workshops which are concerned with some specific aspect of resource development and conservation. Some of these are held at Headquarters in Rome, but most of them are held in the developing regions in order to permit fuller attendance by the technicians and administrators of these countries. By holding these meetings and workshops in the field, we are better able to orient the discussions to the particular conditions and local problems of the area.

Once every two years FAO sponsors a series of five Regional Program Conferences. On these occasions major consideration is given to a general review of the nature and progress of FAO's program in the region, to consideration of ways in which the work can be improved; and to any policy questions that may involve intergovernmental cooperation, the financing of specific activities and, to FAO's working relations with the countries concerned.

According to our rules, any interested member country has a right to participate in all FAO conferences, meetings, workshops, and training activities, even though they are being held in another region. Similarly each country decides on the size and composition of its delegation. This means in practice that many countries are now including more professional people from the various technical fields—technicians draw both from governmental and non-governmental sources.

These technical and policy meetings play an important role in strengthening and improving the substantive work of FAO, in the dissemination of scientific, technical and economic information, and in the formation of greater international cooperation at the working level as well as the policy level.

I might illustrate the importance of these "policy consultations" by an example in the area of wildlife management.

In 1959 our Member Governments decided that FAO should expand its activities in wildlife management, following a twofold approach: first, the promotion of wildlife preservation through various systems of national parks and reserves; and second, the utilization of wildlife as an element of economic development, by treating it as a subsidiary form of production associated with agriculture, stock-raising or forestry. Our view is that good wildlife management can become a means of increasing the production of proteins in a number of underdeveloped areas and perhaps serve as the starting point for more intensive stock-raising and the improvement of natural grasslands. FAO's Regional Forestry Commissions were urged to actively follow these matters. We are also cooperating very closely with the Internatonal Union for the Conservation of Nature and Natural Resources, particularly in Africa. A Symposium on the Conservation of Nature and Natural Resources in Modern African States, called jointly by the Commission for Technical Cooperation in Africa South of the Sahara (CCTA) and the IUCN under the co-sponsorship of FAO and UNESCO, was held in Tanganyika in November 1961. This meeting was attended by 140 participants from 21 African and 6 non-African countries. One of the important results was a decision to organize a team of specialists who would have the job of analyzing the problems of wildlife conservation and management in Africa, of assessing the needs of the countries in terms of education, research and administration and of proposing the priorities for specific projects including suggestions on ways and means of financing and implementing these projects. Other recommendations of concern to FAO related to the expansion of education and training in the conservation of all natural resources, the improvement of land-use planning, and the creation of essential national and local machinery for implementing sound land policies.

FAO has two experts serving on the African Wildlife Management Team. They have already visited most of the countries of Western and Eastern Africa which requested their services, and in 1963 further countries in Western and Central Africa will be served. Among those already covered are: Senegal, Mali, Upper Volta, Chad, the Federation of Rhodesia and Nyasaland, Bechuanaland, Kenya and Tanganyika. This team is being consulted on many related topics—land use and natural resources policies, wildlife management, game legislation, national parks, hunting regulations, education and training, research, promotion of the tourist industry, etc. Although the experts themselves are not in a position to advise on all these matters, they can suggest the types of external aid, under international or bilateral programs, best suited to the needs of the countries, and advise FAO and other agencies on any further action that may be taken.

We have already reached some tentative conclusions that will be of interest although we emphasize that the adaptation of animals and plants to their environment needs to be more fully understood. Different species of grazing animals exhibit variations in efficiency in utilizing vegetation to produce animal protein. Under circumstances now prevailing in East Africa, zebu cattle, for example, are generally in much better condition than European breeds. It appears that many wild animals maintain themselves and even grow and improve on diets which will not support zebu cattle.

Game animals in Africa almost invariably appear better nourished than European cattle in Africa, and are in far better condition than the nomadic stocks. The magnificent condition of zebra and some species of antelope is in marked contrast even to the state of zebu cattle, which, under identical conditions of pasture may be emaciated and dying.

Game would appear to offer great possibilities in some areas as a source of protein for human consumption, if a system of game farming could be initiated. The development of wildlife policies and the conduct of detailed biological investigations will, it is anticipated, tap a promising source of animal protein for human consumption. However, before systematic game cropping can be introduced on a large scale, much information is needed concerning the number of wild game in the area under consideration, their grazing habits, reproduction rate, annual increase, losses from disease and other causes, and their migratory movements. Likewise, ecological considerations involving wild game, nomadic herds and settled farming systems raise questions to which no satisfactory answers have yet been found.

Mr. Chairman, you will have noted that I have largely confined my remarks to the international machinery for cooperation. This does not mean that we are overlooking the valuable experience and results of bilateral programs such as AID, Colombo Plan, various colonial development services and the technical aid programs of other western European countries. This form of intergovernmental cooperation must be continued, and if possible, expanded for some years ahead. Similarly, we should redouble our efforts to establish more institution to institution cooperation in support of conservation and development. The excellent overseas work of American colleges and universities should be extended into various new fields of resource development, including resource planning. These institutions likewise must be prepared to play an even bigger role in the training of overseas personnel.

The experience of business and various voluntary agencies must also be used. Some of these nongovernmental groups have performed most valuable pioneering services in the field of technical aid and self-help programs.

POPULATION AND FOOD SUPPLY

Perhaps one of the most dominating forces in the world today is the unprecedented rate of population growth. We are told by demographic experts that the current rate of increase in world population which is nearly two per cent annually, will have cumulative effects of such magnitude that extreme measures may need to be taken to avoid more widespread poverty and want in many parts of the world. The best predictions are that the present world population of three billion persons will double within the next 40 years. We can realize the significance of this accelerated growth when we recall that it took about 200 years from about 1650 to 1850 A.D. for the world population to increase from 500 million to the first billion. In the next 110 years the population reached the three billion mark. Now in a short period of 40 years the experts predict that the population will double again and reach six billion by the year 2000.

If we look into the food supply situation, we should be disturbed by the fact that 12 to 15 per cent of the present world population are hungry most of their lives and that another billion people suffer from malnurition due to the poor quality of their diets. This means that up to one-half of the world's population are at present victims of hunger—and a great part of them are living in the underdeveloped regions of the world.

The population "explosion" introduces an extremely serious and disturbing element into all of our plans for resource conservation and development. We are forced to speculate whether governments, particularly those of the developing countries, will take early recognition of the significance of these predictions and particularly the pressure that will be placed upon their productive resources.

The developing nations must guard against the hasty adoption of untried cultural practices and other measures for maximizing food resources as the pressure of population becomes more intense. This is a serious matter in many regions because we are already noting more and more proposals that countries short of food should increase the caloric level of their food supply by limiting animal production and by stressing the more directly-consumable human foods—the grains, legumes and starchy root crops.

This may look attractive in theory, and may be advantageous in practice in a very few areas, but under the conditions existing in most of the hungry, underdeveloped countries it may be dangerous advice. What is required in most of these areas is a system of husbandry which will raise the organic matter of the soil, improve soil structure, build up fertility, prevent erosion and convert residues from arable crops by feeding them to livestock, into protein-rich, acceptable human food. Even in countries where large acreages are devoted to exportable cash crops such as coffee, tea, maize, cocoa, sugar, cotton, sisal, etc., there are now striking examples to show that by good farming, with little extra capital, high-protein animal products can be provided in increasing quantity from part of the land previously used for cash crops. As a result of this form of improved 'mixed farming' the total amount of cash crops can be increased even from the smaller acreage available.

Realizing the seriousness of the world food and population situation, the Director-General of FAO, B. R. Sen, with the support of all our Member Nations, launched the *Freedom from Hunger Campaign* in 1960. This Campaign is a bold attempt to muster the available forces in the battle against hunger. It was conceived in the firm conviction that the struggle for food has become the most important human problem in this century. It is being organized upon the belief that the task ahead can only be accomplished through the combined efforts of those who are prepared to dedicate their energy and resources to such ideals. Dr. Sen has said that he hopes the Campaign will "promote a climate of opinion throughout the world in which the problems of hunger and want will be faced realistically, their causes analyzed with detachment, and their remedies sought in a bold and courageous manner. If such a movement can be organized, we may be assured that the necessary corrective action will follow."

The Campaign is an attack upon the *underlying causes of hunger* and malnutrition wherever they may be found, even in the more developed regions where depressed areas and low income groups still suffer from inadequate diets. It seeks to mobilize on a voluntary basis a wider range of knowledge and other resources which can be concentrated upon the problem for a sufficient period of time and with sufficient degrees of intensity to produce the solutions desired.

The activities of the Campaign fall into four broad classes:

(1) Informational and Educational Programs
(2) Research and Demonstration Projects
(3) National and International Action Programs
(4) FAO Guidance and Technical Advisory Assistance to Bilateral projects if requested

The Campaign is receiving unprecedented support from world leaders everywhere and from many different religious groups, voluntary organizations, business and civic groups, labor farmers' organizations and others. Over 50 countries have created national Freedom from Hunger Committees or similar groups to promote the Campaign and to provide an operating link between FAO and the governmental and non-governmental organizations and groups interested in participating in the Campaign. In the United States these functions are performed by a Freedom from Hunger Foundation which has offices at 700 Jackson Place, N. W., Washington 25, D. C. This Foundation has invited all organizations and groups interested in the world problems of food and agriculture to become affiliated with it and to participate in the Campaign activities in whatever manner is most appropriate for them. Those of you who represent organizations interested in any facet of the world food problem, are urged to get in touch with the Executive Director of the Foundation.

The Canadian Freedom from Hunger Committee has also been very active with its 60 affiliated organizations. Others are urged to join. The Canadians are sponsoring a National Food Conference at Ottawa later this month, March 19-20. This conference will study Canada's own food and agricultural problems and potentialities, including developments in food technology, the changing requirements for production and various programs of the Federal and Provincial Governments. I know that the Canadian Committee will welcome any of you that may wish to attend. The address of the Canadian Committee is Box 2034, Station D, Ottawa, Ontario, Canada.

On the information and educational front, FAO is encouraging all countries to observe the *Freedom from Hunger Week* March 17-24 with appropriate ceremonies, particularly of an educational nature. President Kennedy has issued a proclamation urging the people of the United States, through their various religious and private organizations and foundations, to help in the task of "rededicating" men's minds and hearts to the inspiring possibility of working together to free the world from hunger.

Special Freedom from Hunger stamps will be issued in March by 143 postal administrations and the United Nations. The United States stamp will be issued on June 4th, at the opening of the World Food Congress. This *World Food Congress* is another important phase of the Campaign. It will take place in Washington, D. C., next June 4-18. About 1200 persons will attend with at least two-thirds coming from overseas. We are making every effort to obtain good representation from the developing countries of Asia, Africa and Latin America. We are also seeking a good balance of various technical fields as well as administrators, educators, community leaders and representatives of the many non-governmental organizations that are actively supporting the Campaign. The main aim of the Congress is to study the problems and obstacles that must be overcome, to reassess the resources available, to take stock of the progress of the Campaign and to determine how and where greater action must be applied. We expect that the Congress will also help create a greater public awareness of the nature and seriousness of the world food situation.

The work of the Congress will be divided into four main commissions, namely a technical commission; economic and social commission; education and research commission; and finally, a commission dealing with the involvement of people and their institutions in group action.

We hope that many of you present here today will attend the Congress as a member of the United States or Canadian delegations. We hope also that you find other opportunities to participate actively in the Campaign.

Another important phase of the Campaign is a joint FAO-United Nations activity known as the *World Food Program.* This is a pilot project designed to study and demonstrate new ways of utilizing surplus agricultural commodities to support rural conservation and development. The aim is to find more and better ways of using the agricultural surpluses as capital goods in supporting local projects in the needy countries. We know for example that in some kinds of land and water reclamation projects, located in areas of abundant labor supply, it is possible to pay these laborers up to one-third of their wages in the form of food. This has several advantages in these developing regions. It helps control inflation which would otherwise arise from large capital expenditures. It also helps improve the strength and efficiency of the workers and over a period of a couple of years it can help improve their dietary habits especially if the foods are of high nutritional value.

Governments have pledged food, shipping services and cash valued at about 80 million dollars for this three year pilot program. We anticipate that we may undertake 35 or more different projects, many of which will involve land and water development, various kinds of resource reclamation activities, land reform and land settlement, food scholarships for rural education and training centers and others. This World Food Program should provide another good mechanism for promoting cooperation in conservation. Perhaps some of you would like to become associated with this program.

The fight against hunger and wise management of our resources will be a long and uphill battle. It may take a generation to assure that the world has adequate supplies of food. The Freedom from Hunger Campaign is just the first phase of this battle. We need to prepare for long-range programs which will engage the energies and imagination of all nations and all scientists for many years to come. We cannot forget that no nation—rich or poor—can escape the threat posed by the pressures of skyrocketing populations on already inadequate food supplies. But ours is the first generation of human beings with enough knowledge in our grasp to allow us to hope that these problems can be solved before it is too late. We not only have the *knowledge,* but also the *opportunity* and the *material wealth* to meet the challenge.

I thank you.

DISCUSSION

MR. AHMED MAHINDA [Tanganyika, East Africa]: Mr. Chairman, I am a representative sent by the government of Tanganyika and I am only speaking here as a friendly visitor. My work in Tanganyika is with wildlife and in public relations. This consists of traveling through the country, visiting schools and a conference like this, and also making speeches and writing texts in my native language, Swahili. My objective is to try to stimulate public interest in wildlife, because I think that if you want people to take an interest in anything you have to educate them. So, for this purpose, the FAO of the United Nations is allowing me the opportunity to visit this country for 10 months to visit parks, national forests, wildlife refuges in different states, to try to observe the kind of work which is done here. Unfortunately, I am not a good linguist, so I would like to ask you to excuse my broken English, but please try to understand what I am intending to say.

Since I arrived in this country, I have been very interested to see wonderful work which is being done to improve all natural resources, but my disappointment about your work here is that many people in our country and in the rest of Africa do not know of the work which is done in this country, especially in wildlife. I met many friends who had been in this country, some who had been at universities or just as official visitors, and I asked them while they were here what they had seen in this country in the way of wildlife. They said, "Oh, wild animals? Mr. Mahinda, don't dream of that. If you want to see animals, the place to go is only to a zoo." I believed what they said was true, because most of them had been in universities, and most of which are located in the big cities. And also, some of them were here on official business and had been taken to administrative buildings, not to the parks or to offices which are concerned with the management of wildlife. So what they see of their surroundings is only that which is around them, cities and traffic, and those who go outside the city see only farms and livestock, and it is easy for them to say they didn't know there was any wildlife in this country.

It would be of benefit for this country to have people from other countries come over and to educate them by showing them all functions of the different work which is done here. Although some who come here are studying wildlife, others want to become doctors of medicine or engineers, but it would be very good for them during the summertime when the schools are closed to be taken to a national park or wildlife refuge to show them how this country is trying to improve its natural resources.

Another thing that you need to show the visitor is a little about the way that many of your conservation programs are financed, at least partly from the money from the issue of hunting licenses, or show them some of the things which are being done by the private individual.

I say wildlife is very important. We must preserve it. It has been very helpful to me, because I have seen what you are doing. When people say, "No, there is no use to preserve wildlife in this country," I can say "It is very important." I can say, "I have been to America, and they do the same thing." So you are setting a very good example. It is very difficult for people in Africa to realize that wildlife can bring revenue to the country. If you see the condition of the people who depend upon wildlife for profit or eating, the tribes of the Congo or the Bushmen in the Kalahari or some of the other hunting tribes in Africa, you will find conditions very poor in comparison with those of people who live in America. So, we do not have anything to convince these people that wildlife may bring revenue to the country. They say, "What revenue?"

The people do not know they can make money with forests. Why should they believe that wildlife can bring in revenue?

Since I have come here, I have realized that wildlife can bring revenue into Africa. For example, if I had a lion here, and we had a room and I put my lion in one side of the room, and another man took a new model car and put the car in the other side, I think most people in this town will come to see my lion, not the car. This is to show them wildlife is of benefit to the country. So, I know that it is a very easy thing to bring a lion to the city in this country, but if we are unable to preserve the lion in Africa, though, many people come and bring dollars. This is very important. Another example I have seen in this country is that people learn many things by imitation. A few days ago, I read an article in the first issue of *African Wildlife* from the Tanganyika Foundation that a leopard coat of the same kind was worn by the wife of President Kennedy and by Princess Margaret in London. Since then there has been a great demand by ladies who want to wear leopard coats. Some people may make even $25,000 with the leopard skins, and I would say that with conservation measures, we could have a supply of leopard skins for many years in our country, but I have been interested in leopards and all other parts of wildlife. Our people must do these things by coping with the problems, and see what someone else has been doing.

MR. CREIGHTON: Thank you very much, sir. I think that time is getting late, and if you will excuse us, there are some gentlemen who have to catch some planes, and we will have to go along with this.

RESOURCE DEVELOPMENT THROUGH EDUCATION

STEPHEN H. SPURR

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In discussing the role of education in the development of the world's natural resources, one is tempted to restate the obvious importance of natural resources to mankind and the obvious values of education to conservation. This afternoon, at the conclusion of a stimulating and successful three-day conference, I think that we can accept this importance and these values for granted. I propose, therefore, to examine the specifics through which education can help in natural resources development and to highlight some of the recent developments and trends in conservation education that might have come within my own particular purview.

It seems to me that there are three general areas where education is deeply involved in world-wide resource development. The first involves the development of highly skilled scientists, educators and administrators to provide the basic ideas, knowledge, and know-how on which natural resources development must ultimately rest. This area is the prime responsibility of our greatest universities with their complex of graduate offerings and opportunities for individual research and scholarly activities.

The second level of education in natural resources development involves the need for the training of competent technicians and professional conservationists. It is the professional wildlife manager, the professional forester and their counterparts in other conservation fields who must put into practice the measures that will assure wise use of our resources. Their education is primarily at the undergraduate level, and is carried out at a much larger number of colleges and universities, ranging from great university centers to small four-year colleges and to an increasing number of technical schools and community colleges.

Third, education must create an awareness of conservation problems among the citizenry of a country before the people themselves will support and respect programs for the sound management of natural resources. This awareness must be developed in our elementary schools, secondary schools and colleges, as well as in the general populace through radio, television and general extension activities.

No one institution, and certainly no one individual, can function effectively at all three levels. I am not even sure that any one individual can discuss all three knowledgeably and competently. Yet, only through a concerted effort on all three fronts can we achieve the maximization of resource development in the interest of mankind.

Let us, then, examine each of these three general areas, not with a view of generalizing their importance, but rather so as to see past and future developments in the light of the present.

GRADUATE EDUCATION

The identification, training and development of key scientists, educators and administrators through graduate education is, of the roles of education, the most difficult, the most expensive and the hardest to justify in terms of obtaining funds from governmental and other agencies. Yet it is by far the most important. A single new, relevant, and cogent idea may well revolutionize the whole development of a natural resource. No one can predict with any certainty as to when, where and how such an idea will appear but the odds are that it will come from one of a relatively few individuals who not only have extraordinary talents in their own right but who also have been given the opportunity to reflect, study and write so that their ideas will have a chance to develop, emerge and be given a hearing. The overwhelming importance of a great philosopher-scientist cannot be overestimated; nor can the necessity of selecting a few individuals and giving them a favored position in the hope that they will develop into such. Historically, we have the image before us of the monastic scholar in his cell in the middle ages with his disciples, an image drawn in some extent itself from Socrates, Plato and the other Greek philosophers. In our own country we have the characterization of Mark Hopkins on his log—although modern opinion is that the log was never there, only a cabin in the woods. In our own century, we have examples such as Robert Frost as poet in residence at The University of Michigan, George Santayana at Harvard, and Einstein at the Institute for Advanced Studies. Perhaps we too often award the distinguished professorship to people past their stage of maximum productivity rather than to the promising young man who has all the attributes for greatness and needs only the opportunity in which to develop them. Also such singling out tends to expose a man to a constant round of banquets, public lectures and the more idolatrous type of graduate student seminars at which the individual is basking in the light of past achievements rather than drawing upon his resources to make new philosophical contributions to mankind.

At a more practical and down to earth level when we approach the field of natural resource conservation, we are concerned less with the world-famous figure than with the professor-scientist who thinks and works creatively and who gathers about him a small group of graduate students who will carry his ideas—often improved, perfected and further developed by themselves—out into the world. I should add parenthetically that such a professor must not only be a creative thinker but he must also be an "operator" in that the graduate students will flock about him only if it is possible financially for them to do so. This involves a constant effort on the part of the professor to proselyte, to beg and borrow funds, to write grant applications. He must excel in grantsmanship as well as scholarship. He must know how money available for one purpose can be used for a deeper and more creative purpose at the same time while satisfying the requirements for which the funds were made available.

Fortunately we have such men in natural resources in the United States today, although they are far too few. In any given aspect of a given natural resource field we can hope to identify two or three such individuals who give form and substance to that particular field. These men may be in any university or educational center. Usually, however, they are more apt to be found at one of the ten or twelve great complex university centers around the country which as a result of these men and others like them have developed national reputations and a climate which attracts, encourages, and holds the few that succeed in making the university great. Sometimes, though, they are found at lesser institutions. In my own experience, for instance, I was drawn into the field of natural resources biology in a small department at a deep southern university which for a brief span of years served as a rallying point for intellectual stimuli in the field of invertebrate zoology.

It is to these few men and the personal schools that they establish that we must look for the major stimulus in natural resource education. The men themselves may not have the attributes we normally associate with greatness. They may not be good speakers, good writers, or necessarily even clear thinkers. They may have many eccentricities and many shortcomings. Nevertheless, they will have that rare spark of enthusiasm and intellectual honesty which pierces the fog of scientific convention and ignites similar sparks in the minds of the young men they instinctively draw around them. In the last hundred years in the United States we can identify several such. Nathaniel Schaler, the Harvard geologist of the last century was one. Much of the form of the present-day forestry profession has been given to it by such men as Gifford Pinchot (although not a professor or teacher in the usual sense), H. H. Chapman of Yale and Filibert Roth, Donald M. Matthews, and Samuel T. Dana of Michigan. I choose my illustrations from forestry rather than wildlife management because of my own familiarity with the men I name. We could go on into teachers still active today, but I think the point is made.

Strangely enough such men as I have mentioned, and whom I could mention in greater number, frequently make their major contributions on human thought not in their area of major training and competence but in disciplines peripheral to it. I sometimes think that all of us are too indoctrinated in our major fields to be really free thinkers. It is only when we apply our own somewhat regimented thinking with enthusiasm and a certain amount of ignorance to related disciplines that we sometimes score a major breakthrough in knowledge. Admittedly such breakthroughs are infrequent in comparison to the blunders that make the field-jumper anathema to the specialists in that field. We must remember, though, that these very specialists who may be stodgy and dogmatic in their own area of specialization, may make substantial contributions to ours.

All of this points to the fact that the major intellectual contributions to the world-wide development of natural resources through education will inevitably come from the tongues and the pen of a relatively few individuals at a relatively few great universities working under relatively few restrictions and limitations with a relatively few graduate students who will eventually carry their message and their ideas to the rest of the conservation world.

PROFESSIONAL TRAINING

Few of the students spoken of in the previous section will in turn themselves become great scholars and leaders of human thought. Most of them will eventually end up as administrators, scientists, and educators who spread through their lives the ideas that they received in their youth. So it is that professional training will frequently lag about a generation behind current leading thought in a given subject. Nevertheless, in this country it is competently and intelligently handled so that we are developing in the natural resources fields professional curricula in which we are turning out unparalleled numbers of agriculturists, foresters, wildlife managers, fishery scientists and conservationists. Indeed, at the present time, the field of natural resources management is opening up to the point where we can see in the near future the development of new types of specialists in such areas as recreation management, water resource management and even air resource management. A brief consideration of each of these fields may be of some value in identifying the nature and trends of professional training in the United States. These trends in turn inevitably affect professional training in the world as our country is today the center of the world wide natural resource training and as the books written in America by American scientists exert a key role in influencing world natural resource thinking and professional training.

Scientific agriculture is the oldest of our natural resource professions, but the training of scientific agriculturists pretty much began in the 19th century. In fact we have only just recently celebrated the centennial of college-level scientific agriculture in the United States at the University of Massachusetts and Michigan State University. Although indisputably perhaps the major natural resource science, agriculture, by very reason of its size and importance and also by reason of the increasing intensive management of agricultural production by man, has become a field in itself and falls largely outside of the topic currently under discussion.

It is forestry that perhaps best typifies professionalism in natural resource training, for it is in this field that the outward trappings of a profession have been most fully developed exposed and defined. Scientific curiosity and interest in our forests is as old as similar interests in our fields. Theophrastus, Pliny, and others of the ancient writers have treated the forests in detail. Professional forest management, however, can best be dated from the beginning of the 19th century in Germany arising from the teachings and writings of Heinrich, Cotta, Robert Hartig and others. In the United States, interest in forestry grew not so much out of agriculture as out of the interests of gentlemen land owners reflected in the liberal arts universities of the East. Thus lectures were initiated in forestry in the Department of Political Science at The University of Michigan as early as 1881, these being given by Professor Volney Spaulding of the Botany Department, whose great-nephew, incidentally, heads our forestry department today. Gifford Pinchot, having graduated from Yale and having studied forestry later at the famous French school at Nancy, came back as the first professionally-trained American forester to establish the U. S. Forest Service and the Society of American Foresters, and to persuade his family to endow the Forestry School at Yale with his college roommate Henry Solen Graves as its first dean. Land-grant colleges were not long in countering with forestry programs of their own with the result that we now have some 27 forestry schools accredited by the Society of American Foresters in the United States alone. Thanks in part to strong leadership throughout the century, and in part to the existence of large and strong forest land management organizations such as the U.S. Forest Service and many of the pulp and paper companies, forestry is now an established profession in its own right in the United States. It has a society, membership in which is restricted primarily to graduates of accredited forestry schools. It publishes its own scientific and technical journals. It prescribes certain courses that must be taken and degree levels that must be met before a man can call himself a professional forester and be employed as such in many public agencies. At the present time, it also is pressing for state boards of registration such as in Georgia and Michigan where men can qualify for registered status as foresters and identify themselves as such in their professional activities.

I hope you will excuse me for stressing the field of forestry in what is essentially a wildlife conference but this is the natural resource field with which I am best acquainted. It is also the one which for better or for worse is giving considerable guidance and direction to the development of professionalism in other fields. Certainly, range management and wildlife management have to a large extent evolved along with the forestry profession and are only now splitting off and setting up shop completely in their own right. Both groups are following the general pattern of forestry leading to the establishment of a true profession but with the wisdom of added years of experience and with a knowledge of problems particular to their own disciplines.

Fisheries management, however, has developed and is developing more out of the science of zoology than from the agriculture-forestry axis. Indeed, fisheries today is still largely a biological science and most fisheries scientists are primarily biologists rather than resource managers or social scientists oriented to fisheries problems. It is only in recent years that fisheries programs have been separated in some instances from zoology programs at American institutions; and it is only very recently that in some institutions, fisheries have become allied with the land-based natural resource professions in a School of Natural Resources such as we initiated at The University of Michigan in 1950.

Coming to the field of conservation, we inevitably become involved in semantics. Conservation means many things to many people. It began as a protectionist philosophy aimed at isolating nature from man and preserving what was left of man's heritage from the wilderness. To many people it still is. For others, conservation has been redefined as "wise use" and thus includes the broader, more philosophic, and generalized aspects of all aspects of natural resource study and management. At my own particular institution, however, conservation is evolving still further from generalized concern for our natural resources to a specific concern for the socio-economic aspects of natural resource evaluation, planning, allocation and use. Our conservation department is becoming the focal point wherein the social scientist can undertake interdisciplinary studies of the relationships between man and the natural resources upon which he depends. As this trend develops, and as we begin to identify specific training in specific courses and specific disciplines with the production of specialists in these areas, conservation is becoming less an esoteric catch-all and more of a profession. I think that we can foresee the development of conservation as a true natural resource profession within the next decade, although possibly under the guise of a different name.

The disciplines that I have mentioned are all established in natural resource training, although albeit with varying degrees of professional status at the present time. As we conceptualize natural resource problems, though, and as we look at the impact of increasing populations and increasing urbanization upon the world around us, other natural resource professions are beginning to evolve. Recreational management, for instance, is of outstanding popular interest and importance today. The activities of the Outdoor Recreation Resources Review Commission increased public interest in our national parks and in outdoor recreation generally. The establishment of the new Bureau of Outdoor recreation and the evident interest of the public in these developments is sparking rapidly expanding interest in research and in education in the field of outdoor recreation. A National Conference in Outdoor Recreation Research is scheduled for Ann Arbor in May of this year and has attracted an interest and an enthusiasm that would have been inconceivable to most of us two or three years ago. Certainly additional professional training is indicated in this general field, although we are still far from clear as to what extent concepts involved in the field will be embodied instead into forestry, wildlife management, fisheries and conservation.

Certainly of more economic importance, though, and probably of greater importance in all respects in the long run is the field of water resource management. The conflicting uses of water for human consumption, industry, recreation, transportation and waste disposal are rapidly reaching a point where, even in the favored Great Lakes area, water is the one factor most limiting to growth in populations, industry and human satisfaction. Yet, water resource management is still in its infancy. We are only beginning to accumulate the basic data upon which we can base the economic studies necessary for the wise political allocation and management of water resources. Personally, I foresee water resource management as possibly the most important of the professional natural resource activities in the decades ahead.

In closing this brief survey of professional training in natural resources, I should like to point out that air as well as land and water must be managed. Locally, air pollution is as serious as water pollution and wildland devastation in affecting human habitation, industry, and health. Smog is only the most obvious symptom. While these problems are most extreme in industrial areas such as Los Angeles, Pittsburgh and London, they exist in increasingly important measure in many other centers of population. In fact, when we add our concern with radioactive pollution, air management involves the entire world. To air pollution, we can add the possibilities of weather control in the evolving field of air resource management. Up to now, we have been largely concerned with cloud seeding to increase local rainfall and such devices as heaters and wind machines to prevent frost inversions at the growing level of cold susceptible crops. In this science, however, the space age is rapidly changing the picture entirely. From our artificial space satellites capable of reconnoitering daily much of the world, we are accumulating climatic information at an unprecedented rate. It is not beyond the realm of possibility that our atmospheric scientists may soon begin to understand weather and climate for perhaps the first time, and that, with this understanding, we may be better able not only to predict but even to modify and occasionally even alter weather itself. In any event, air resource management is certain to evolve along with water resource management as a major profession in which man's intellect is oriented toward meeting conservation's world wide challenge.

PUBLIC EDUCATION

The foresters, wildlife managers and professional conservationists will not, of course, directly effect resource development themselves—or at least not without the help and support of a conservation-oriented public. So it is that these professionals must through public education reach the public and develop an awareness at all levels that will eventually be reflected in legislation, financial support and action necessary for actual natural resource development, conservation and management. Speaking as I do at the end of a three-day meeting, and being not particularly competent in the important field of public education, perhaps it would be best for me to avoid restating the obvious importance of public education in conservation and to close my paper by drawing attention to a few recent developments of special interest here.

First of all, I am sure that you are all aware that we have made considerable progress in recent years in building conservation thinking and conservation knowledge into the total curriculum of elementary schools and high schools. Through conservation specialists, conservation education workshops, and special programs offering teachers the opportunity to major in conservation, we are beginning to reach substantial numbers of the teachers who are most responsible for moulding the minds and concepts of our youth. Perhaps most important of all, conservation specialists are beginning to co-author school textbooks, an example being a high school biology text co-authored by Richard Weaver of my own school.

I am particularly impressed by an experiment scheduled to begin at The University of Michigan next fall. Here we are attempting to reach a broad spectrum of college students with a rigorous and scholarly course on natural resources ecology designed to teach the principles, theories and problems of natural resource management rather than to serve as a simple catalogue of conservation activities. This course, to be taught by Professor Stanley A. Cain, has been accepted by the College of Literature, Science and the Arts as satisfying their distribution requirements for a non-laboratory course in natural science such as is required by all of the students to meet the requirements for their Bachelor's degree. Whether or not the course will succeed in its purpose remains to be seen. Nevertheless, the acceptance by a liberal arts faculty of a natural resources course presented and taught by a professional school is in itself worthy of note and promising in its long range implications.

Another area of great importance in public education in natural resources development lies in the ability of an occasionally great writer to reach a large perceptive audience and influence them with his clearly presented ideas. We all know how much we owe in American conservation development to Thoreau, Burroughs, Muir and the other great naturalists of the last century. Fortunately for us this skein of writers has continued into our present time for in Aldo Leopold, Marston Bates, Rachel Carson, Peter Farb and others we have authors who not only have the capacity to think for themselves but also to communicate their ideas effectively to the public at large. The effectiveness of these and other popular writers cannot be underestimated.

Neither can we ignore the enormous potentialities of educational radio and television. Nature films have become popular at prime hours on commercial television. Educational television shows produced by university television studios and others have demonstrated remarkable longevity and achieved surprising acceptance. Every once in awhile I am surprised to find my own face reappearing on the screen in unexpected parts of the country as a result of some modest and really not very good television programs I made some years ago. Currently our University is producing a major series of educational television programs on water and these, I am sure, will be spread over time and space without the necessity of our blushing as a result.

In closing, I cannot help but feel that the type of session that we are currently attending is among the most important means of educating an important segment of the public in natural resource development. The North American Wildlife and Natural Resources Conference is one of the most important, best conceived and well managed of a world-wide network of meetings dealing with natural resources, conservation and management. Through its scientific sessions, its general sessions and the many related meetings under way in Detroit this week, almost all of the aims of public education in natural resource management are being carried out. It has been a real privilege for me to have been invited to address the general session. I know that I for one have profited a great deal by listening to the papers and discussion that has preceded my own rather feeble effort. Thank you.

PART II

TECHNICAL SESSIONS

TECHNICAL SESSION

Monday Afternoon—March 4

Chairman: NORMAN C. WILDER
Director, Delaware Board of Game and Fish Commissioners, Dover, Delaware

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Assistant Director, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida

WETLANDS AND INLAND WATER RESOURCES

INVENTORY OF WATERFOWL ENVIRONMENTS OF PRAIRIE CANADA

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Prairie Canada, according to some reports, was once a verdant region of lush marshes that produced each year countless millions of waterfowl. Now it is widely thought that these marshes have been ravaged by drought and drained for agriculture; . . . unless they can be rehabilitated, the waterfowl of North America face disaster.

At some variance with this familiar story are the following facts. True marshes amount to a very minute 3/10ths of one per cent of the total number of potential water areas in Prairie Canada. Since they are found usually in old glacial drains and stream valleys where alkali salts collect, such marshes are relatively untouched by agriculture. They serve waterfowl not so much as brooding areas, but rather as

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moulting areas where post-nesting adults gather in midsummer to grow new flight primaries (and sometimes to die in the sporadic plagues of botulism that break out in such places).

In view of such divergence of information, there would seem to be great need for an accurate, comprehensive picture of the waterfowl environments of Prairie Canada. The picture should be so sweeping in scope that it would show this great region with all its parts in focus, and in perspective with adjoining waterfowl nesting regions that are even more vast; yet detailed enough so that it could serve waterfowl management in the way that regional soil surveys assist agriculture. This report describes an extensive-intensive appraisal of prairie waterfowl environments, made under fortunate circumstances, that was designed to catalog them and map their location and extent. It attempts to orient these environments with respect to their long-term utility for waterfowl, so as to picture the fabulous "Prairie Duck Factory" the way it probably looks to a duck.

HISTORY OF APPRAISALS

Knowledge of Prairie Canada's waterfowl habitats has been accumulating, especially after the great droughts of the 1930's brought to the attention of waterfowl conservationists the importance of the grasslands and parklands of Saskatchewan, Alberta, and Manitoba. But much of this information came from studies of certain localities or specific environmental conditions; so long as we had no workable catalog of prairie environments, nor charts that would show where and to what extent certain environmental conditions prevailed, it was difficult to determine the applicability of past and current researches and reports and to plan future inquiries.

In 1947, when numerous conservation agencies pooled their resources and started annual surveys that eventually encompassed most of the breeding grounds of North American waterfowl, the air crews and ground teams assigned to the manifold Prairie Canada operation immediately sought to map out the major waterfowl environments of that region (Williams, 1948). This job could be pursued only incidentally to more pressing matters such as the determination (for regulatory purposes) of annual status, distribution and reproductive success of waterfowl populations. During the early 1950's, a wetlands survey of the United States (Shaw and Fredine, 1956) inventoried the waterfowl ponds and marshes of the Northern Plains States, and the need for extending the inquiry to adjacent Prairie Canada then became more urgent.

Yet the "gray area" between the general and the specific persisted, not only because of lack of opportunity to make appropriate surveys, but also because of the almost total absence of criteria for evaluating such habitat data as we were able to get. Some prairie environments are so mercurial in their day-to-day aspect that the data produced by two consecutive coverages of the same area might at first glance give the impression that two different areas had been surveyed. An "average" condition for such an environment would seem to be a logical standard, but its determination would require a knowledge of the frequency and degree of the good and bad, throughout the entire range of suitability of that environment for waterfowl. In this regard, climatologists require a 20-year unbroken record of observation for any prairie weather station (and would prefer a 30-year record) before placing much confidence in its average temperatures, precipitation, and other station statistics. Establishment of any corresponding statistic for the waterfowl utility of a prairie environment, considering as it must such diverse and variable matters as soils and topography, agricultural and other human intervention, response of mobile bird populations, as well as cumulative and current weather might require an even longer period of continuous observation. There was one possible alternative. If we could ever once catch Prairie Canada at its hypothetical peak of attractiveness for nesting waterfowl, the conditions then prevailing could serve as an ultimate standard against which any subsequent lesser level of suitability could be gauged.

During the early 1950s Prairie Canada was blessed with unusually heavy precipitation (Kendall and Thomas, 1956), and by 1954 its waterfowl environments were becoming wetter than they had been in recent decades (Lynch, 1956). This seemed to be the opportunity we had been hoping for. In order to grasp it before it evaporated, and to cover the 220,000 square miles of grasslands and parklands that sprawl between Winnipeg and the foothills of the Rockies, an aerial appraisal of the region was decided upon. Methods of classifying lands and waters and of recording data were developed in 1953 and early 1954. Most of the actual flying of the survey pattern was accomplished in the summers of 1954 through 1956, usually when our aircraft (a Piper PA-18) was "deadheading" to or from other assignments or returning to fuel points. The aircraft and crew were available full time during May of 1957 to finish the job.

SURVEY PROCEDURE

The survey pattern consisted of 11 aerial transects (Figure 1) that ran east to west across the provinces of Manitoba, Saskatchewan and Alberta. These strips followed township lines where range-line jogs or "corrections" simplified the task of navigation.

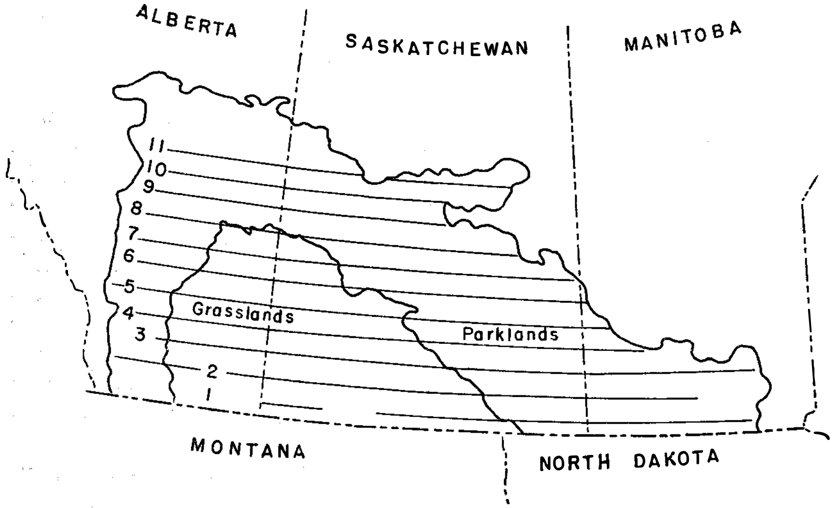

Figure 1. Layout of air transects in prairie Canada waterfowl habitat inventory

The first transect was located 12 miles (2 townships) north of the Canadian-United States border, and subsequent transects were spaced 24 miles (4 townships) apart. The transects were flown at altitudes of 2,000 to 4,500 feet. They totaled 4,608 linear miles in combined length and are considered to be a representative sample of the 220,000 square miles of Grasslands, Parklands and adjacent cleared Aspen forest of the three Prairie Provinces. The route was planned in such manner that it can be duplicated exactly should a future appraisal be decided upon.

This survey was intended to be both extensive and intensive, and no one procedure can do justice to both objectives. Therefore the appraisal actually involved two operations that were conducted simultaneously. As the plane flew down the transect mid-line, one observer scanned a strip 12 miles in width (one township north and one township south of the mid-line), while the other focused his full attention on a strip one-half mile in width (Figure 2). Each survey was designed so that it could stand on its own merits as an independent sample of the Prairie Region, yet both were tied together in such fashion that each pair of townships (72 square miles) of the extensive survey, which produced only subjective information, was "sampled" by 3 square miles of the more precise and detailed intensive survey. Control of sample proved relatively simple in the Prairie region, for

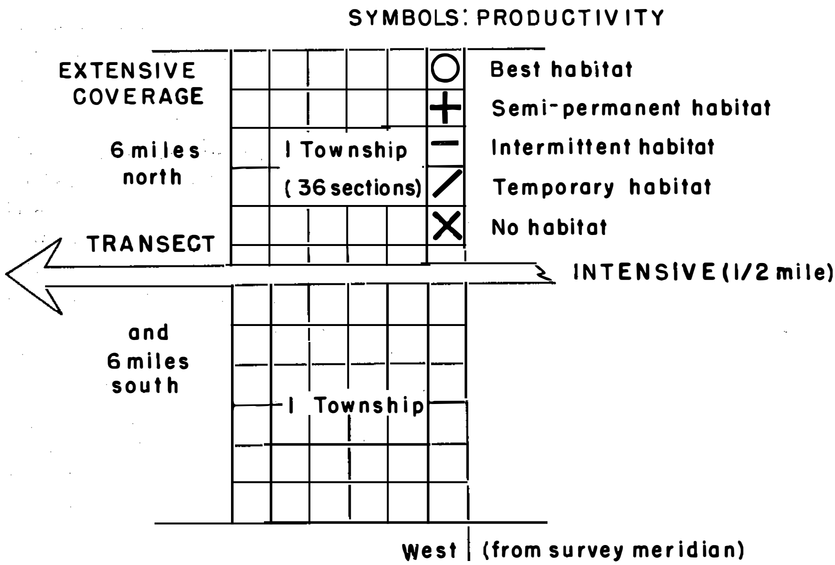

Figure 2. Air-transect traverse through 6 miles of narrow and wide strip.

aerial observers could recognize townships, sections, and fractions of sections by means of road allowances and fencelines.

The intensive survey was concerned primarily with the types and amounts of nesting cover (including that of uplands) that might be available to waterfowl, the water areas that could serve as courtship, brooding and moulting ponds, and the extent to which both could be (or already had been) intruded upon by agriculture and other human activities. So it recorded (from the ½-mile wide traverse through each section) the topography (level or nearly so, undulating, rolling, eroded escarpment, dissected plateau, stream valley, or open water), and the predominant land use (moderately farmed, clean-farmed, grazed, mixed farmland-pasture, forestland, urban). Then it recorded the numbers and sizes of all water areas of categories listed in Table 2 that contained water at the time of observation, or if dry, had recently held water for a period long enough to produce a discernible effect on zonation of native vegetation, or (in the case of cultivated lands) had imposed obvious limits on human activities. All this information was talked into a recording device installed in the aircraft. A pattern of calling was developed that enabled the observer to record a large amount of data in such fashion that it could be transcribed on specially prepared tabulation sheets with comparative ease. Usable intensive survey data were obtained from 2,304 square miles, approximately a 1% sample of Prairie Canada.

The observer making the extensive survey was interested primarily in gross appraisal (for mapping purposes) of the terrain adjacent to each unit of the intensive survey. This rough appraisal was intended to give somewhat greater scope, via an expedient that was admittedly subjective, to the more precise but attenuated objective inventory; it culminated as a mapping-in of the various waterfowl-producing lands of Prairie Canada, and a ''mapping-out'' of non-productive sections. In scanning and recording on tape each square mile the observer had in mind a hypothetical 10-year period during which prairie weather in its usual peripatetic oscillation, would range from the very wet through normal to the very dry. Seeing the land during the middle-1950's when it was almost as wet (and therefore potentially as productive) as it was ever likely to be, he speculated whether each section could be expected to be productive of important numbers of waterfowl most years of the hypothetical decade, or some or just a few, in view of its terrain and soils, human uses, and water economy. Incidently this observer, from his vantage point of altitude, had under surveillance a vast amount of country (over 1,200 square miles if visibility were only 20 miles), and so he had in view at any given time examples of Prairie Canada's best and worst environments, against which the sections under examination could be compared. It might be mentioned that the waterfowl experience of observers in this survey team included a collective total of nearly 10,000 flying hours (the equivalent of one million ground miles); much of this flying was in the Northern Great Plains and Prairie Canada, over terrain the observers had studied from the ground at various times, during good waterfowl years and bad, as far back as 1935. Usable subjective information from this extensive survey totalled 55,296 square miles, a 25 per cent sample of the Prairie Region.

After the surveys were completed in 1957, the data they produced were transcribed from record tapes, and tabulated by township and by transect. Eventually all of this detailed information was carded for machine sorting, and cards are now on active file at the Patuxent Wildlife Research Center, Laurel, Maryland. Maps that give the general information produced by the extensive survey, and preliminary analyses of findings of the intensive portion of our appraisal, have been furnished to the various conservation agencies presently engaged in the Joint United States-Canadian waterfowl program.

More precise analysis of the detailed data can now be made by machine.

Thus some of the ''gray area'' between the specific and the general can now be filled. If, for example, a local study should develop a new waterfowl management procedure that is effective for one type of environment, machine sorting of our appraisal data will quickly tell us where and to what extent this procedure is applicable to Prairie Canada. Should the question be one of involving the specifics of some general environmental condition, the machine data together with our extensive survey charts can produce the answer to that also. But these answers will represent only facets of a picture that still lacks historical, geographic, and ecological perspective. The following observations may help supply the missing colors.

THE PRAIRIE-DWELLERS

Prairie Canada is semi-arid. All who share in the use of its grasslands and parklands, be they farmers, cattlemen, or the various forms of prairie wildlife, are ever aware that the environments they jointly occupy are water-critical. Prairie dwellers look mainly to the atmosphere for enough fresh water to sustain a prairie existence, and there are times when this very dry atmosphere takes away, through evaporation, more moisture than it brings. So all users of prairie lands and waters arrange their pattern of living in deference to a water supply that usually is less than ample, and is always capricious. Man and most other prairie mammals measure their water supply in terms of available soil moisture; for waterfowl and the other wetland creatures, water means *surface-water.*

Prominent among the plants and animals of the aquatic environments of the region are many species that would be considered indicators of intermittent waters. Some other species that might be expected to be common in the innumerable small ponds of the region are conspicuous by their absence. Thus the submerged and emergent-aquatic zones of most small prairie ponds feature a curious mixture of the ''wet meadow'' (slough-grasses, smartweeds, etc.) and incipient "northern bog" (sedges); the traditional pondweed-bulrush aquatic associations are confined to the larger ponds. The principal fish of the small ponds are not the pike, the muskellunge or similar trophies, but are more apt to be such oddities as the tiny stickleback; many of the best waterfowl rearing ponds have no fish of any kind. For a region whose wetlands are thought to be almost as extensive as its uplands, water mammals such as the muskrat are curiously scarce in many places, while ground-squirrels and other dry-land mammals are remarkably abundant. Among the aquatic crustaceans the most successful are those that are quite tolerant of drying. Of the waterfowl, the long-lived geese and northern divers that have a relatively slow rate of replacement (the "perennials" of the waterfowl world) seldom nest here. The waterfowl that do nest in Prairie Canada, in such numbers as to affect materially their continental status, are the mallard, pintail, shoveler, baldpate, gadwall, and bluewing and greenwing teal of the dabbler group, and the canvasback, redhead, ringneck and ruddy; it is interesting to note that all these ducks are relatively short-lived species with great reproductive potential, being in one sense the avian counterpart of the "annual weeds" of the plant world.

The grasslands and parklands of Prairie Canada are no longer wilderness. They now comprise one of the world's most important agricultural regions. The conversion of prairie sodlands to farmlands, once started, progressed with startling speed. In 1901 a mere 5 million acres were farmed in Prairie Canada, but ten years later this acreage had increased to 23 million, and by 1936 a total of 60,850,000 prairie acres was under cultivation (Dickson, 1943). During our aerial appraisal in the middle-1950's, 72 per cent of prairie lands was recorded as agricultural, in crop or summer fallow. Since the intensity of farming will influence the waterfowl utility of environments, our appraisal recorded separately those agricultural lands that were clean-farmed. We found that more than half of prairie grainfields were farmed so intensively that little trace of native vegetation remained at pond margins or in the ponds themselves. On such fields, which amounted to 38 per cent of all prairie lands (Table 1), the principal ground cover now consists of growing

TABLE 1. CHARACTER AND USES OF PRAIRIE LANDS

Percentage recorded as:	Alberta Grass-lands	Alberta Park-lands	Saskatchewan Grass-lands	Saskatchewan Park-lands	Manitoba	Prairie Percentages
Topography:						
Level to undulating	18.0	3.0	28.3	25.9	40.1	24.7
Moderately undulating	47.0	46.2	37.7	58.2	40.7	47.3
Rolling	22.6	43.1	19.0	12.5	11.8	19.2
Eroded, etc.	11.5	6.4	14.1	2.5	7.4	8.0
Other	0.9	1.3	0.9	0.9	tr.	0.8
Human Use:						
Moderately farmed	11.5	29.3	10.3	34.9	36.8	24.7
Clean farmed	27.3	26.9	43.9	43.6	37.9	38.0
Grazing	32.0	15.5	22.2	4.9	5.4	15.0
Mixed farm and pasture	28.9	26.3	22.9	13.4	17.8	19.0
Other	0.3	2.0	0.7	3.2	2.1	3.3
Utility for nesting ducks						
Permanent	3.0	1.2	4.7	4.7	3.6	3.8
Semi-permanent	4.1	6.2	5.0	10.9	10.4	7.7
Intermittent	18.8	29.1	12.1	36.0	15.6	23.3
Temporary	71.0	59.4	64.3	47.0	43.1	56.1
None	3.9	4.1	13.9	1.4	27.3	9.1

crops, stubble from the crops of the previous growing season, and agricultural weeds. Much stubble is plowed each year, either for direct seeding, or in summer-fallowing programs designed to control annual weeds and conserve soil-moisture; a start has been made at control of weeds with herbicides, which operation may remove in some part the need for plowing of stubble on fallow land.

Our survey recorded 15% of the prairies as being given over entirely to grazing, and another 19% was placed in a "mixed farm and pasture'' category. The former were for the most part sodlands in the strongly-undulating, rolling or hilly terrain, although some of the extensive grazing lands of east-central Alberta and west-central Saskatchewan represent abandoned farmland that has reverted to (or been planted to) grass. In the farm and pasture mixture are relatively small farm plots, interspersed among planted forage or hayfields and native pastures.

Thus man has changed profoundly the prairie environments he shares with nesting waterfowl. Farming and grazing, taken together, now influence 96.7% of this region, and slightly over 1/10 of the remaining 3.3% is given over to urban development. Certain localities are now so dominated by man that their remaining waterfowl utility is very slight indeed; in some environments nesting waterfowl seem now to lead a more precarious existence because farming and grazing have constricted native cover so that nests are more vulnerable to predators, and have encouraged pintails and mallards to nest in grain stubble that may be plowed up or burned before their eggs can hatch. Yet waterfowl continue to nest in Prairie Canada, sometimes in great numbers and with great success. Perusal of our appraisal data for topography and land use shows that the lands best-suited for farming are not (and never were) the most dependable regions for waterfowl. Quite the contrary, the intensity of prairie farming is almost inversely proportional to the inherent long-range utility of the land for nesting ducks. The clean-farmed regions lie mostly in the rich heavy soils of glacial lake beds (Glacial Lakes Regina, Agassiz, etc.), where a level or gently-undulating terrain foreordained that ponds would be shallow and very transitory. The rolling morainic terrain that has the most durable waterfowl ponds is not likely ever to be clean-farmed, especially where gravelly soils forbid such use.

Therefore it would be oversimplification to label ''destructive to waterfowl" all the changes man has wrought in Prairie Canada. The waterfowl significance of these changes cannot properly be assayed unless one looks back into the past, to see what has been altered, and in what manner. The authors of this paper, in viewing Prairie Canada at its recent ''pinnacle'' of wetness, found themselves so often seeking to project back into the past (as well as forward into the future) the environmental panoramas of the middle-1950's, that they decided to be deliberate about it. Weather-records maintained by the Canada Department of Transport, and historical accounts of the settlement of the prairie region, were of great help in this speculation. History tells us that before beef cattle came to the prairies, the region was often overgrazed not only by bison and the other large herbivores, but also by rodents and insects (Bird, 1930). Long before native vegetation was affected by the plow, it was sporadically but ruthlessly swept by prairie fires. Climatology tells us that the prairie region, throughout its known history, suffered precipitation deficiencies that frequently attained the proportions of drought; waterfowl reproductive success must have been very low during these very dry periods of the past, a situation that is not greatly changed today (Lynch, 1962). Also unchanged are the capabilities of prairie environments (given enough water) for spectacular production of waterfowl; during the wet middle-1950's nesting waterfowl appeared to be as successful on lands that were clean-farmed or overgrazed as they were in environments that had not been so greatly disturbed. Some changes such as the building of stock ponds and small reservoirs in the more arid environments have been a benison for waterfowl.

After all, man did not move into Prairie Canada for the express purpose of destroying its waterfowl environments. Had such been his intent, the region would have been settled in a manner quite different than it actually was. Despite all the changes man has brought to the prairies, it is difficult to find anything he really "destroyed," unless it be whatever semblance of equilibrium might once have prevailed in environments that always were uproariously dynamic. His intervention does represent a potent element of disturbance, replacing some of the disturbing forces already operating there, augmenting others, and counteracting some. To gauge and express the waterfowl import of this new disturbance, the hypothetical decade we employed in our extensive appraisal offers itself as a useful frame of reference. By this expedient, an environment that under pristine conditions would have been productive of waterfowl 4 or 5 years out of the decade might, after some human alteration, be seen to be productive 3 or perhaps 2 years of the period; yet subsequent intervention by man might render it more productive than ever before. Of course any comparison of today's prairie waterfowl conditions with those of the distant past will of necessity be imprecise, but need not be unrealistic. For the future, it is hoped that the information produced by our appraisals may serve as a reasonably firm standard for environmental conditions of the middle 1950's, against which further alterations of the prairies may be evaluated with greater accuracy.

PRAIRIE WATERS

Our appraisal disclosed that there can be as many as 6,661,400 water areas in Prairie Canada. In remarkable agreement with this figure, which represents potential units of surface water, are the records of actual water areas tallied (although not classified) in the course of annual waterfowl surveys of the Prairie Provinces; at their recent peaks of wetness Saskatchewan reported 4,264,000 (Lynch, 1956), Alberta 1,252,000 (Smith and Jensen, 1956), and Manitoba 1,006,000 (Hanson and Gilmore, 1957) for an ultimate total of 6,522,000 units of surface water. These totals do not necessarily represent ''ponds'' in the strict sense of the word, but rather are surface water basins or depressions that can hold water *when they get water*. Some 97% of these basins have no source of water other than precipitation, and so will contain only such rain-and snow-melt waters as fall directly into basins, or that trickle in from the surrounding terrain. Table 2 classifies and shows the corresponding types of these water areas, generally following Martin *et al.* (1953). From the standpoint of utility for nesting waterfowl, these water areas might be re-classified into the "most abundant," the "best," and "the rest."

The most prevalent, and at first glance the most worthless of prairie water areas are ''puddles.'' They may number in the millions when snows melt in spring, or at any time of summer when rains are very heavy, and appear as flooded areas in stubblefields or as casual puddles or sheet-water in plowed lands, especially those with heavy soils. The ''A'' puddles listed in Table 2 had no surviving native vegetation at their margins at the time of observation and obviously were subject to being plowed through and planted in dry weather. They proved so ephemeral that a percentage figure for their ultimate abundance (51.8% of prairie water areas) may be otherwise misleading; the number-per-square-mile figure for the various categories (Table 2) catalogs all water basins in such a way that fluctuation in the number of puddles will not affect the numerical standing of the other water areas.

One might well wonder if such puddles have any utility for waterfowl. During the early part of each nesting season, they are used very extensively by migrant ducks and geese that rest briefly in Prairie Canada in their spring journey to more northerly nesting grounds. The prairie-nesters seem to find such puddles admirable as waiting-sites during the courtship period. Occasionally great num-

TABLE 2. SUMMARY OF PRAIRIE WATER AREAS

Number per square mile of:	Alberta Grass-lands	Alberta Park-lands	Saskatchewan Grass-lands	Saskatchewan Park-lands	Manitoba	Expanded To Prairie Indices
Puddles ("A")	5.29	14.47	8.63	27.07	14.62	3,411,450
Potholes ("B"-1)*	3.39	5.88	3.71	14.86	10.34	1,870,200
Potholes B-2 (open)**	1.84	1.52	0.99	2.19	1.82	378,100
Potholes B-2 (shoal)**	1.94	2.99	1.22	3.11	2.05	502,800
Potholes B-3 (open)	0.89	0.96	0.58	0.74	0.76	167,000
Potholes B-3 (shoal)	0.59	0.88	0.41	0.72	0.29	126,650
Sloughs "C"-4 (open)	0.21	0.27	0.11	0.14	0.10	33,950
Sloughs C-4 (shoal)	0.06	0.21	0.07	0.08	0.04	18,150
Sloughs C-5 (open)	0.06	0.07	0.04	0.04	0.03	10,000
Sloughs C-5 (shoal	0.01	0.01	0.01	0.02	0.02	3,250
Lakes	0.02	0.01	0.01	0.02	0.03	4,000
Reservoirs	0.17	0.09	0.18	0.06	0.07	24,700
Dugouts	0.18	0.03	0.34	0.28	0.35	56,800
Beaver-dams	0.01	0.02	0.01	0.01	0.01	2,000
Streams***	0.22	0.33	0.22	0.15	0.22	52,330

*Size designation: "1" is less than one acre in extent and is completely overgrown by vegetation; "2" is one to ten acres or if smaller is open and deep; "3" is eleven to forty acres; "4" is 41 to 160 acres; "5" is larger than 160 acres.

**"Shoal" ponds had half or more of surface showing emergent plants (bottom-rooted); "open" ponds are normally so deep that emergents are confined to shores.

***Indicates number of times transects crossed streams, and does not reflect actual number of streams.

NOTE: Category A is equivalent to Types 1 or 2 (but no native vegetation surviving) of Martin et al. (1953); category B-1 is Type 3 (or 2 if still in native vegetation); B-2 and B-3 are equivalent to Types 4 or 5; and B-2 (shoal) and B-3 (shoal) are Types 3, 4, 6, or 7, depending upon size, or if strongly alkali, may be Types 9 or 10.

bers of pintail and mallard broods appear in flooded stubblefields. These broods grow to maturity, seemingly nurtured only by ''muddy water and wheatstraw.'' Upon close examination, this flooded stubble may be found to be literally swarming with aquatic insects and small crustaceans. The incredible richness of this mixture of wheat-straw, warm water and good soils calls to mind the ''hay infusion'' that is used by teachers of elementary biology to demonstrate the sequence of invertebrate forms of aquatic life. This simple laboratory demonstration seems to be duplicated some wet years in the prairies, on a scale almost too vast to comprehend. At any rate waterfowl sometimes can raise broods in prairie stubblefields, and presumably could do so occasionally in aboriginal times when these fields were still in native grasses. The intrinsic long-term waterfowl utility of ''puddles'' would be considered low, yet prairie waterfowl productivity is apt to be phenomenal in years when such ponds are very abundant, and usually is mediocre when they are scarce. These may have some hitherto unsuspected utility for waterfowl, but it is more likely that a great abundance of puddles merely reflects a general climate that is overwhelmingly favorable for watefowl reproduction.

Good *potholes* are the heart of the fabulous "Prairie Duck Factory.'' All of the ducks that use the smaller ephemeral water areas for courtship or nesting must have, within easy reach, these more durable waters (Evans and Black, 1956) for the rearing of their broods. The emergent vegetation of these admirable rearing ponds furnishes nesting cover for canvasbacks, ruddies and other divers. Our survey placed 46% (slightly over 3 million) of Prairie Canada's potential water areas in a general "pothole" category, which included basins or circular depressions wherein the native vegetation of the aquatic and shore zones had thus far resisted the encroachment of agriculture. But of this total, only 1,174,550 had basins of perceptible depth, with well-defined "plow-proof" edges or shorelines, and watersheds that were greater than 10 times the size of the actual pond area.

Sixty-one per cent of the "potholes" listed in Table 2 proved to be small (less than 1 acre in size) and their shoal basins were overgrown completely with bottom-rooted grasses and sedges in the grasslands, or willow, alder or aspen in the parklands. Some parklands are so liberally dotted with these tiny water-holes that 120 or more of the category may be recorded on one square mile of land. Some farmers are willing to put up with the inconvenience of plowing around the small wet areas. But others are clearing the tiny potholes at every opportunity and plowing them through when the soil is dry enough to do so. Once the native vegetation of any small "B-1" pond has been removed, the cleared pothole then would become an "A-1" pond in our classification. It is doubtful whether clearing alters very much the original waterfowl values of these smallest potholes. They are too shallow to have been dependable brooding areas, even in their pristine condition; whether cleared or not they continue to function as courtship areas and may even harbor broods so long as they do hold water. It could be said that most of the "B-1" potholes we recorded in the parklands would long ago have been converted to "A-1" puddles had it not been for the fact that their woody vegetation made them a more formidable obstacle to farming than their grassland counterpart.

Our transects failed to disclose any instances of the serious pothole drainage that has been reported (Schrader, 1955) from the Northern Plains of the United States. This does not mean that no potholes have been drained in Prairie Canada. It merely signifies that such drainage was not extensive enough at the time of our survey to be detected by the sampling method we employed. Should this drainage become more prevalent, its extent and importance can be monitored by future re-runs of our tansects or parts thereof. Incidently the prairies have always been plagued by "straight-up" drainage (evaporation) of soil and surface water into a very dry atmosphere; this form of "drainage," often overlooked, must have been greatly aggravated when native plants whose phenology was geared to snow-melt water in spring were replaced by agricultural crops whose greatest water demand comes in the water-critical months of midsummer.

"The rest" of prairie water areas have moderately-large or even very extensive watersheds that they can draw upon for their water supply, but in them some new waterfowl problems appear. Prairie *sloughs* are found in old glacial drains and valleys, where out-wash of mineral salts (magnesium sulphate and sodium sulphate) often produces "alkali" deposits. *Lakes*, the larger *reservoirs*, and *continuous streams* are the most durable of prairie water areas, but are generally lower in basic productivity than ponds with fluctuating water levels. Predaceous fiish, particularly the northern pike, become a problem to waterfowl reproduction in these drought-proof and "winter-proof" waters. In summary, it might be said that the most abundant of prairie water areas are the most ephemeral, yet these have remarkable capabilities. The best of these water areas, the 1,174,550 *good potholes* of the 3,044,750 "B" ponds listed in table 2, have serious shortcomings, for they have no assured water supply other than precipitation that falls directly onto their very circumscribed watersheds. There is nothing unusual about "the rest" of prairie waters; the prairie lakes, reservoirs, beaver-ponds, etc. are much the same as their counterparts in the non-prairie breeding regions of North American waterfowl, some being fair to rather good in waterfowl values, but falling short of the phenomenal in production of ducks.

"PERMANENCE"

The extensive portion of our appraisal, while designed primarily as a mapping operation, also disclosed that only 3.8% of Prairie Canada was blessed with reservoirs, lakes, or other waters that would not go dry under any natural circumstances (Table 1). At another extreme was the 9.1% of the prairie region that consisted of eroded or deeply dissected terrain, sandhills, and other lands that are not now (and probably never were) suitable for nesting waterfowl. 7.7% of the region was catalogued as "semi-permanent" waterfowl environment, but in making such identification, the authors became increasingly aware of the fact that "permanence" of water did not in all cases constitute permanence insofar as waterfowl utility was concerned. A substantial proportion (23.3%) of Prairie Canada was designated as "intermittent" in waterfowl productivity, for its waterfowl environments would have been dry almost as often as wet in our hypothetical 10-year period. The remaining 56.1% of the prairies was recorded in a "temporary" waterfowl utility category; such lands had remarkable capabilities, but these were seldom realized unless brought out by unusually propitious weather.

Implicit in most classifications of prairie lands and waters is the philosophy that "the Permanent" is somehow a desideratum. And so it is perhaps inevitable that prairie environments be catalogued in terms of their relative failure to attain this state. Such procedure may be admissable so long as it serves only as an expedient for classification. When it comes time to interpret any ratings, as to waterfowl utility, of environments that are notoriously unstable and whose biota is correspondingly kaleidoscopic, a seeking for degrees of "permanency" seems incongruous.

Viewed from a somewhat different angle, whereby the tendency to be perpetually water-logged is recognized as only one (and quite possibly not the best one) of many waterfowl capabilities of lands, the most durable of the aquatic environments of Prairie Canada are seen to be the most placid. Those having the least durability have explosive capabilities, as do the short-lived, fast reproducing birds and invertebrate animals that occasionally frequent their evanescent waters. The great preponderance of the impermanent environments, and their spectacular (although sporadic) productivity for waterfowl, lend credence to the idea that the various prairie lands and waters we have catalogued represent a "Community of Environments," reminiscent of, although on a scale much greater than, the community of water areas already described by Nord et al. (1951) and Evans and Black (1956). Wherein the most durable of prairie environments serve as oases of waterfowl survival during periods of water deficiency, and from which breeders can proliferate into the "intermittent" and eventually into the "temporary" environments at such times as the latter become habitable. This concept, which might be considered analagous in a broad geographic and temporal sense with the community stratification of Allee et al; (1949) is well-known to entomology (Chapman, 1931) and epidemiology, and the survival value of low-capacity habitats has been pointed out by Linduska (1950) for certain mammals, and by Lynch (1952) for prairie waterfowl.

A waterfowl "Community of a Third Order" may be recognized when Prairie Canada is seen in its entirety and in perspective with adjacent breeding-grounds of North American waterfowl. To an aerial observer, the prairie region is sometimes drab, but at other times will scintillate in the midst of its more somber and relatively placid surroundings (the boreal and other non-prairie waterfowl environments). If the latter can be considered dynamic, and they are although rather gently so (Lynch, 1940), then it could be said that Prairie Canada's environments, into which ducks may swarm and out of which they may explode, are nothing short of "dynamitic."

This seems to be the way our waterfowl see the fabulous "Prairie Duck Factory" . . . . not so much as a self-sufficient entity, but rather as an assemblage of integral parts that have graduated potentialities for productivity, and which taken together represent only part (although a very explosive part) of a much larger biotic community. It might be a good way for us wildfowlers to look at Prairie Canada.

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DISCUSSION

MR. WILLIAM LEITCH [Winnipeg]: The comment that I would like to make on John's paper is that perhaps a little more emphasis might have been given to the value of semi-permanent areas. I know John said there wasn't much danger of them being drained, but at the present time in Canada we have the problem of expanding beef production which expects by 1970 to increase the number of beef cattle by one and a half million animals. The pressure is now on for hay. The unfortunate part is that the large temporary marshes which we have to have to carry the waterfowl through the semi-drought periods are the ones that are most susceptible to being drained and tilled for hay production. The problem is to maintain these areas.

I think we all agree with John that the temporary ponds give us the boom in waterfowl population, but we also need the semi-permanent areas to carry us through the bust.

MR. JAMES BROOKS [Alaska]: We who have seen the duck-producing areas in the prairie feel that the North Country is often underestimated with respect to production, particularly during the bust years on the prairie. The country beyond is vast, and conditions there are relatively constant, both within a given season and from year to year. I was wondering what significance Mr. Niester placed on this northern area from the standpoint of production relative to that on the prairie during the four years.

MR. LYNCH: I'm glad you brought that up, Jim, and what I have to say is apropos to what Bill Leitch said also. I did place a somewhat low key on the importance of the more durable habitat of the prairies and of the country north of the prairies, although only with the intent of emphasizing the explosive capabilities of the less permanent habitat.

From the standpoint of the annual duck crop, there is a certain dependability about these environments that both Jim and Bill have mentioned that cannot be overlooked. Anything we do to preserve them is certainly very much to the good in terms of the annual duck crop. Furthermore, what makes the prairies so spectacular is the fact that now and then they explode their production. We can't have an explosion without detonators and I think that these semi-permanent areas that both of these gentlemen speak about are the detonators that kick off these explosions when other conditions decree that it can happen.

DR. HAYNE [North Carolina State College]: I would like to comment on this as a method. I would like to point out that here is a man who says in a sense that he can look at the land and tell you something about it even though he doesn't say he can put this or that ruler on it; but he does have it marked down in a quantitative sense. You may have missed the fact that he points out that he covered about 25 percent of this really very large area.

Now, this is a method of extensive application; I think it's a very fine thing because too few investigators are willing to go on the line and put down what they think about the land, which will include all of their experience and knowledge, even though they cannot state, square mile by square mile, why they decided that this was a good or a poor production area.

MR. PAYNTER [Saskatchewan]: I might say that I really enjoyed Dr. Lynch's paper because he certainly sizes things up.

The point that he hasn't brought up is that since he has been coming up to Canada, in the last three years we have seen the organization of permanent drought areas. Our farmers have been bringing in big machinery and have been pushing all of the brush into the big potholes. They're now draining off some of the marshes, and unless somebody says something quickly to show other values beside grain and grass for our prairies, it's going to be a permanent drought.

FISHWAYS ON EASTERN RIVERS

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The need for fishways has been debated ever since colonial times when the first dam was erected across an Atlantic Coast salmon stream. In Pennsylvania, legislation was adopted by the Colonial Assembly as early as 1724 to demolish and remove "fishing dams, wears and kedles set across the river Schuylkill." Six years later another law was enacted to prevent "the erecting of dams, wears, etc., within Schuylkill." Continuously since then the problem of fishways in dams has received much attention throughout North America.

At the first North American Wildlife Conference in Washington, D. C., Raymond W. Dow (1936) spoke on the restoration of Atlantic salmon to the Penobscot River. He reported the destruction of the abundant and valuable commercial salmon fisheries in the lower portion of this river system and the plans for restoring the runs by building fishways with WPA labor and financed by state appropriations. At the Conference in 1946 Wayne Heydecker reviewed the work of the Atlantic States Marine Fisheries Commission designed to restore Atlantic salmon to the principal rivers in Maine. The Maine legislature had authorized a salmon study commission in 1945 to investigate the problem and to recommend correction. The current report of the Atlantic Sea Run Salmon Commission (1962) has reviewed the recent excellent progress in this promising field. They now have workable fish ladders as part of their program of restoration.

Since Colonial times Pennsylvania has had an almost continuous problem in attempting to provide for fish passage around the various dams of the Commonwealth which have obstructed the passage of migratory fish, particularly shad. Prior to 1900, shad fishing on the Susquehanna River was an industry of considerable economic significance second only to that of the Delaware among coastal streams. Stevenson (1899) of the U. S. Fish Commission of the Department of Commerce estimated that the annual catch at that time was at least 500,000 shad in the Pennsylvania portion of the river. By 1910 the quantity of shad in the Susquehanna had been greatly reduced presumably because of dams, over-fishing and to some extent by pollution of the river.

Construction of dams at York Haven (1904), Holtwood (1910), Conowingo (1928) in Maryland about ten miles above the headwaters of Chesapeake Bay and Safe Harbor (1931) for power genera-

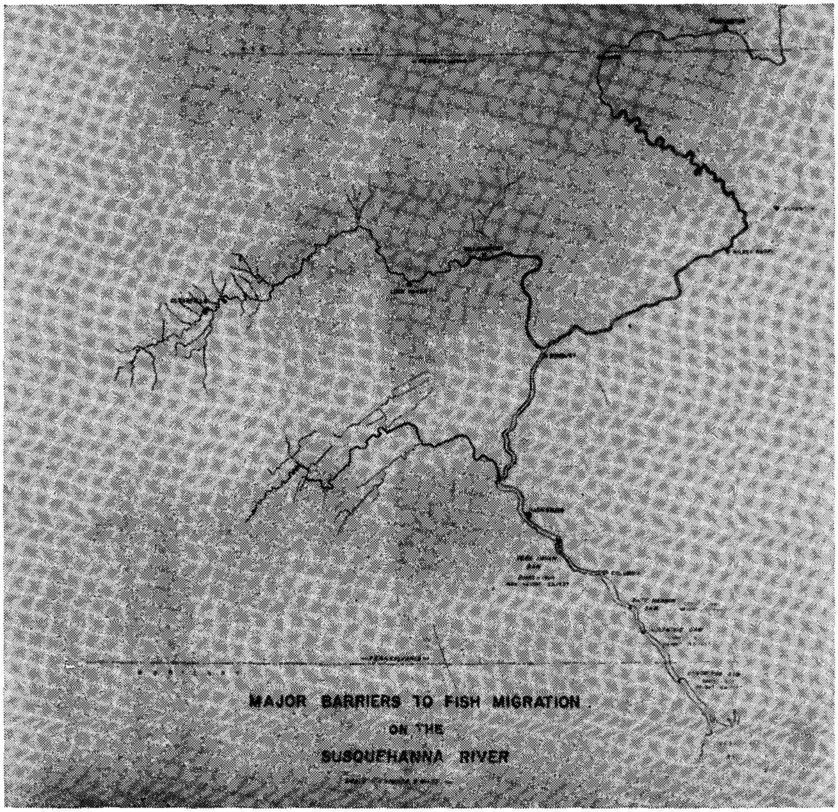

Fig. 1
Fig.1. Major waters of the Susquehanna River Drainage showing location of principal dams which block migratory species.

tion on this stream have since blocked spawning migrations of shad from salt water into Pennsylvania. (Fig.1).

Pennsylvania law years ago provided that anyone erecting or maintaining a dam in the waters of the Commonwealth must make provision for free passage of fish at all seasons of the year. Where this is not practicable the Board of Fish Commissioners at present may require in lieu payments to the Commonwealth not exceeding $6,500 per year. The law also provides that money received from these payments is to be used for stocking fish above the dams or for other fish management purposes.

The attempts to provide for fish passage around the dams along the eastern coast prior to 1900 are well summed up by the statement of Stevenson (loc. cit.), "Numerous attempts have been made by the erection of fishways to enable shad to pass above these obstructions (dams). Among the costly contrivances of this nature are those in the Savannah at Augusta, the Santee at Columbia, the Potomac at Great Falls, the Susquehanna at Clarks Ferry, the Husatanic at Birmingham, the Connecticut at Holyoke, the Merrimac at Lawrence and the Kennebec at Augusta. And although these are modern constructions designed by engineers of ability, familiar with the principles of hydraulics and the habits of fish, none of them appears to be successful for shad, this fish being so timid that it will not enter fishways used by salmon, alewives and other species.

When fish passage for Conowingo Dam (constructed in 1928) came up for official consideration in connection with the Federal Power Commission license for construction of their dam the U. S. Commissioner of Fisheries (O'Malley 1923) reported to the Federal Power Commission as follows: "It is very doubtful if shad would ascend a fishway of any description of any height."

In 1949 the Pennsylvania Joint State Government Commission conducted a study of the Susquehanna fishways and in a report (1949) published that year, L. E. Cable of the U. S. Fish and Wildlife Service testified that "many types of fishways have been constructed at dam sites and rivers of the east coast but none has accomplished the avowed purpose of permitting the passage of shad over the dams." This report also credits Dr. R. E. Coker of the U. S. Bureau of Fisheries with the conclusion that no fishway has been designed which would work successfully for shad under the conditions that existed at the Holtwood Dam in 1916.

Mansueti and Kolb (1953) upon the basis of their extensive review of the history of shad fisheries stated, "A review of the few instances in which shad are recorded as using fishways before 1900 on the eastern coast indicates that either the success of the fishways was accidental or the observation were faulty. The biological requirements of shad are usually not taken into account during the planning and construction of the passes."

In compliance with a request by the Pennsylvania State Legislature to determine the feasibility of fishways in the Susquehanna, the Fish Commission in 1959 employed the internationally famous team of fishway experts from the West Coast, Milo Bell and Harlan Holmes, (1962) to conduct a thorough study of the dams on the Susquehanna River and, if considered feasible, to develop plans for fish passage around these obstructions. Fish passage devices for shad were to be planned by these consultants since it was agreed that if shad could be passed successfully any other species desiring to migrate through the dams would be accommodated.

The consultants first reviewed the literature on the subject of fish passage, particularly shad, in the waters of North America. They also personally visited the mechanical fishway at the Holyoke Water Power Company's dam at Holyoke, Massachusetts on the Connecticut River since it was known to be passing shad successfully. They also examined the newly built Little Falls fishway on the Potomac which although properly constructed has not as yet attracted any shad for passage because of present meagre or non-existent runs of these fish to this point.

The consultants, of course, were thoroughly familiar with the fishways on the Columbia River system and other rivers on the West Coast since they had personally assisted in designing most of these successful structures. "The Annual Fish Passage Report at Bonneville, The Dalles and McNary Dams" of the U. S. Army Engineers (1962) showed that about 450,000 were tallied across the counting boards at Bonneville Dam some 180 miles upriver on the Columbia. Considerable numbers of shad were also recorded at the John Day Dam another hundred miles upstream from Bonneville after having passed the ladders at the intermediate Dalles Dam. Positive records have been obtained of myriads of downriver-migrating young shad at Bonneville proving that facilities there are successful for passage both ways.

In order to be certain that devices recommended for fish passage on the Susquehanna would be utilized by shad, experimentation was necessary to determine the best size and shape of fishway compartments, the most suitable depth of water, velocity and point of entrance of the water, the greatest possible drop between compartments which would be utilized by shad, and many other details. It was also necessary to develop the most effective methods of transportation of adult shad around the dams by truck in order to provide for the reestablishment of upriver runs.

Since shad have been found to have a strong homing instinct it will be necessary to have several generations develop in the Susquehanna above the dams in order to insure increased runs to the lowermost dam in the system, the Conowingo. At present only a few thousand adult shad are thought to reach this dam. With proper trapping facilities most of these would be available for capture and transfer upstream. It may also be necessary to supplement this transfer with the planting of eyed eggs or fry to suitable upriver areas until good runs are reestablished and fishways are constructed and functioning.

Originally, it had been planned by the consultants to conduct fishway experiments with shad in facilities which would be constructed at the Conowingo Dam. However, when the fine experimental facilities at Bonneville were offered to the consultants it appeared logical to shift the experimental work there. In connection with developing fish passage facilities for dams on the Columbia and elsewhere where dams were being constructed by the U. S. Corps of Engineers, a well equipped laboratory costing about $500,000 was developed below Bonneville Dam and has been in continuous operation since. This laboratory has facilities for testing the reactions of fish to various currents, light conditions and different sizes and shapes of compartments, etc. In other words, the facilities there are designed to determine the most efficient type of fishway for any situation and for any species of migratory fish. Here the work was done with shad by the consultants and the design of the fishways and procedures for passage of shad on the Susquehanna were developed. The shad now using the fishways on the Columbia are offspring of original plantings of eastern shad moved from the Hudson River to the West Coast late in the 19th century.

In August 1962 Bell and Holmes submitted their report which now provides the blueprint for fish passage plans around the Susquehanna dams. It was the opinion of the consultants that providing conditions upriver are still suitable for shad and other migratory species and the costs can be justified, fishways around the dams are practical and feasible.

The Pennsylvania Fish Commission has accepted this report and has requested the Federal Power Commission to order the construction of the first phase of the program at the Conowingo Dam in Maryland just south of the Pennsylvania line. The work is to be undertaken in a series of steps with careful checking to be certain that the initial plans are satisfactory and if not, to make any modification in the designs which are necessary as the work progresses.

The first phase as planned by the consultants is a short ladder with a standard trap to catch shad and other fish which still have a natural urge to move upstream. These adults will then be hauled above the uppermost dams to reestablish the runs which at one time reached northern Pennsylvania and southern New York.

If the initial phase proves successful as expected, fish passage facilities would then be installed over all four dams so that fish could move naturally into the upper waters of the Susquehanna drainage.

To round out this study, Robert J. Bielo, a senior aquatic biologist of the Fish Commission, has made numerous field checks and has consulted with the U. S. Geological Survey, the U. S. Public Health

Service and the State Health Department. All of these agencies have been making water quality studies of the Susquehanna River for many years. Mr. Bielo has determined that much of the Susquehanna River system should still be suitable for shad.

These fish and others that might pass the dams should find adequate spawning areas in the various parts of the river which are not now seriously polluted. Considering that adults are able to pass through the pollution of the lower Hudson, lower Delaware and lower Connecticut Rivers, which are believed to be more grossly polluted than the Susquehanna, and that the young that are produced in these streams are able to return to the sea successfully, there seems to be no reason why shad should not find suitable conditions on the Susquehanna River for propagation and development of young. Hazards of downstream passage over spillways and through turbines should not be any greater at these dams than are encountered at power installations on these other rivers.

At the request of the Fish Commission, the U. S. Fish and Wildlife Service made an economic study to determine whether restoration of the shad to the Susquehanna River system could be justified. A report signed by John S. Gottschalk, Regional Director of the Northeast Region for the Service, presents the following statement: "We have made the evaluation on the assumption that the various problems related to the rehabilitation program can be resolved successfully and that the Susquehanna River again will be capable of supporting runs of shad and other anadromous species.

"We have also assumed that the remaining suitable habitat in the main stem and in the lower segments of the West Branch and the Juniata River would produce on a level with similar areas of other major shad rivers of the Atlantic Coast.

"On these premises we have estimated that a run of 500,000 shad annally could develop. A commercial harvest of 750,000 pounds valued at $150,000 could be taken annually in Chesapeake Bay; this would be a harvest in addition to fish taken from populations not migrating above the dams. Some 25,000 shad could be taken by sport fishing both in the Maryland and Pennsylvania portions of the river, furnishing 25,000 fisherman days, to which we have assigned a net recreational value of $75,000.

"We feel that passage of eels and limited numbers of blueback herring, hickory shad, and white perch could result in an additional 10,000 mandays of fishing annually in Pennsylvania with an assigned recreational value of $10,000.

"Based upon prescribed dollar values, this could give us total sport and commercial fishery benefits of $235,000 annually if present water quality conditions throughout the basin are maintained. We see no basis at present for anticipating any losses suffered by sport or commercial fisheries below Conowingo Dam as a result of fish passage construction.

"Reduction of pollution, opening up the North Branch and upper areas of the West Branch, would add significantly to the shad habitat available and, if fully accomplished, could approximately double the size of the run. Other migratory fishes would be relatively unaffected. Total sport and commercial fishery benefits under improved water quality conditions could reach $460,000 annually depending on the extent of the cleanup.

"The present worth of an annual value of $235,000 for 100 years at 2⅝ per cent amounts to over $8 million, while that of an annual value of $460,000 amounts to over $16 million. We mention these values to indicate the range of investment which might be considered justified at this time to bring about the values anticipated from restoration of a shad run in the upper Susquehanna River Basin. Costs involved in addition to construction of fishway facilities would include expense of establishing a population with the urge to migrate to the reaches upstream from the dams, annual operation and management costs which might be connected with the restored fishery, and any cleanup action to remove pollutants from additional areas of suitable shad habitat."

Together with the U. S. Fish and Wildlife Service and the other states concerned we are now in the process of developing plans for carrying out the initial phase as recommended by the consultants including the research necessary to verify the assumptions and to modify original plans as this may prove to be necessary. I am sure that the anglers of Maryland, Pennsylvania and New York can look forward to full restoration of the once important shad and eel fisheries of the Susquehanna River. We also can expect at least a limited fishery for striped bass which originally went upriver from the mouth some 30 to 40 miles. It is even possible that landlocked populations of striped bass may develop in the large impoundments as they have elsewhere along the Atlantic Coast. It is also expected that runs may develop from upper Chesapeake Bay of walleye, yellow perch, white perch, catfish and perhaps other species. The return of the progeny of all of these species should build up populations in the Bay and make significant contributions to the improvement of commercial and sport fisheries in this area as well as upriver. Also since young shad and herring are important forage species for bass and walleyes, it is expected that resident populations of these fish should benefit by the improved food supply.

The proposed restoration of migratory fish runs is of especial significance considering the Delaware River development plan which will pose similar problems for the passage of migratory fish. The Susquehanna program may also be helpful in leading to restoration of runs of migratory species in other rivers of the eastern coastal region where for many years dams have blocked or reduced these fisheries.

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WILDLIFE IN THE SMALL WATERSHED PROGRAM

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Several years ago Mr. James T. McBroom, Chief of the Division of Technical Services in our Washington Office, wrote an article on fish and wildlife in small watersheds for the *Journal of Soil and Water Conservation.* Except for the drainage of wetlands, that article expressed a generally optimistic attitude toward the fish and wildlife potential of the Small Watershed Program. This attitude still prevails in our Bureau in spite of a number of setbacks that have plagued the orderly advancement of fish and wildlife aspects of the program. The adverse effects of this program on fish and wildlife, I understand are particularly prevalent in the southeastern part of the country. It is the purpose of this paper to illustrate some of the effects of the Watershed Protection and Flood Prevention Program on fish and wildlife in only the northern Middle Western States.

The Watershed Protection and Flood Prevention Act was signed into law in August 1954 and is commonly known as Public Law 566 (83d Cong., 68 Stat. 666). Section 103 of the Food and Agricultural Act of 1962 (Public Law 87-703, 87th Congress, approved September 27, 1962), amended the cost-sharing provisions of the Act for fish and wildlife and recreation, generally broadening their scope to provide opportunity for local organizations, particularly State fish and game agencies to develop fish and wildlife resources of public significance as an integral part of multiple-purpose watershed projects.

In this paper some of the results of the Small Watershed Program have been compiled for an 8-state area consisting of Minnesota, Wisconsin, Michigan, Ohio, Indiana, Illinois, Missouri, and Iowa.

As of June 1, 1962, our Regional Office in Minneapolis had received 237 watershed applications for consideration. This substantial number of applications is large enough to illustrate some of the effects of the program thus far on fish and wildlife in the North Central Region.

As of January 1, 1963, 128 of these projects had received approval for technical planning assistance. Sixty-four projects, or 50 per cent of those receiving technical assistance, had been authorized for installation.

The files of the Minneapolis Regional Office contain work plans for 59 of the 64 watershed projects under construction or completed. The watershed area of these plans totals 2,421,118 acres or an average of 41,035 acres per watershed. Data contained in these plans were used to construct the Summary Table on page 3.

SUMMARY TABLE OF
IMPROVEMENTS PROPOSED IN THE 59 WATERSHEDS
AUTHORIZED FOR CONSTRUCTION

LAND TREATMENT MEASURES			
Terracing	5,958	(miles)	100 miles per watershed
Grassed waterways	6,717	(acres)	114 acres per watershed
Farm ponds	1,952	(number)	1 farm pond every 2 square miles
Forest management	173,311	(acres)[1]	2,937 acres per watershed
Hedgerow plantings	16,008	(rods)	would surround sixty 40-acre plots
Streambank improvement	13.9	(miles)	
Spring development	19	(number)	
Tree plantings	13,165	(acres)	1 acre per 183 acres
Wildlife area improvement	3,813	(acres)	1 acre per square mile
Ditches	148	(miles)	192 feet per sqare mile
Open drains	1,678	(miles)	2,336 feet per square mile
Tiles	1,237,357	(rods)	5,280 feet per square mile
STRUCTURAL MEASURES			
Channeling	489.4	(miles)	8.3 miles of channeling per watershed
Stabilization structure	1,568	(number)	1 per square mile
Sediment pool	1,479	(acres)	
Floodwater structures	270	(number)	1 per 14 square miles
Sediment pool	5,260	(acres)[2]	
Floodwater pool	19,199	(acres)	325 acres per watershed
Water supply pool	4,501	(acres)[3]	

[1]Includes hydrologic stand improvement, cattle exclusion, sustained yield management, fire protection, and stand improvement.
[2]Includes additional cost-shared acreage designed for fish and wildlife on French Lick Creek Watershed, Indiana.
[3]Cost-shared with local towns.

It is generally quite simple to demonstrate the value of structural measures to fish and wildlife. Such measures as grade stabilization and floodwater-detention reservoirs often result in silt storage pools which may provide habitat for fish a well as nuclei for adjacent wildlife habitat. The pools are generally quite deep, seldom less than one surface acre in size and quite often have surface areas up to 40 acres and even 100 acres in size. Except in our northern States, fishable lake-type waters are limited and any impoundments capable of supporting fish life receive heavy fishing use.

As a general rule, fishery benefits are fairly easy to recognize. Proposed impoundments, although of sufficient size to support fish life, normally do not have the capacity to maintain the increased flow necessary to benefit a downstream fishery. Where cold-water fisheries are involved, the Soil Conservation Service, cooperating with State conservation agencies, has usually made an effort to protect such waters, especially where production habitat is involved. On occasion they have modified their structures to allow free passage of fish.

Land treatment measures, as contrasted to structural measures, are often nebulous in character and difficult to appraise. A good example of this is the category in the Table titled "Wildlife Area Improvement." It is interpreted to be made up in part of small, scattered parcels of waste or idle lands, some of which may not undergo any change in land use with the project, yet may be claimed as a wildlife benefit for planning purposes.

In analyzing the overall effects of the watershed work plans summarized in the foregoing Table, most of the land-treatment measures except drainage were considered to be generally beneficial to wildlife including songbirds and other wildlife not included in the category of game. On this basis it is estimated that if all of the prescribed land-treatment measures are conscientiously carried out, about half of the projects considered will be of some benefit to wildlife, and the other half will be neutral in their effects.

State participation in the Watershed Program as well as some of the special fish and wildlife developments which have been incorporated in various watershed projects are worthy of note.

Indiana has had 19 applications approved for planning assistance. Two of these included measures which were cost-shared by the Department of Conservation. French Lick Creek Watershed, embodying a 120-acre multiple-purpose pool, is one of these. The other, Elk Creek Watershed, cost-shared a 50-acre lake along with a 330-acre game management area.

Wisconsin has one work plan in which there has been fish and wildlife cost-sharing and has two more with proposed cost-sharing under consideration. In addition, Wisconsin has accomplished considerable wildlife habitat improvement work on watershed projects without cost-sharing.

Wisconsin has a number of watershed projects located in the driftless area of the southwestern part of the State. This area is rugged, quite heavily timbered, and used primarily for dairy farming. Stream gradients are steep and flash floods are common. Some of the recommendations made for projects in this area provide that:

1. Structural modifications be adopted for fishery management purposes.
2. All spring heads be fenced off from farm animal use.
3. Grazing of steep wooded slopes be eliminated and the acreage of improved pasture be increased in lieu of timberland grazing.
4. Sediment pools be established behind all detention structures to provide habitat for warm-water fishes.

Results of these recommendations to date have shown that:

1. Effort has been made to design structures to allow free movement of trout through an impoundment area.
2. Some spring-head areas have been fenced to develop trout ponds.
3. Progress has been made to pasture cattle and hogs in improved pasture instead of grazing them on timberlands.
4. Sediment pools generally provide habitat for warm-water fishes

and tend to become focal points for the establishment of upland game, big game, and terrestrial furbearers.

In Illinois the Tiskilwa Watershed Project, developed primarily for flood control for the Town of Tiskilwa, is located in hilly, wooded terrain used primarily for dairy farming. Four retarding structures were built, one with a permanent 99-acre pool, and three having a total of 35 acres in sediment pool. A heavily-utilized bluegill-bass fishery was developed in the permanent pool. Both the permanent and sediment pools attracted waterfowl to the extent that a new recreational resource in the form of waterfowl hunting was created. Furbearer use of the watershed also increased.

While Missouri has had no work plans with fish and wildlife cost-sharing to date, it has done much in the way of improvement on watershed projects without the benefit of cost-sharing. At present, they have five projects on which cost-sharing is under consideration.

Missouri's primary interest has been in marsh development below project impoundments. Also, they have been active in the development of farm plans for wildlife as well as the construction and development of farm ponds.

Iowa has at least 27 projects approved for technical assistance but none of them include cost-sharing for wildlife. However, general habitat improvement has been accomplished in connection with a number of the watersheds by the Iowa Conservation Department.

Ohio has two projects under construction which include substantial allocations for fish and wildlife developments. Several others now in the planning stage may include similar developments.

Five projects in Minnesota contain proposals for fish and wildlife cost-sharing on reservoir, stream, and marsh improvements. None of these projects, however, has been authorized for installation.

The North Branch of Two Rivers Watershed in northwestern Minnesota contains a proposal for a single-purpose fish and wildlife structure to be constucted to impound a 351-acre shallow reservoir for waterfowl-management purposes. It will be financed through a cost-sharing agreement with the Minnesota Department of Conservation.

The Rush-Pine Creek Watershed located in Winona and Fillmore Counties in southeastern Minnesota resulted in the construction of about 40 farm ponds, most of which are fenced. In addition, grazing of the critical erosion areas has been eliminated by fencing to permit revegetation. The use of the area by breeding waterfowl has increased due to the presence of these numerous, well-dispersed farm ponds.

On the Coon Creek Watershed, Minnesota, a plan was developed to retain some of the wildlife values of extensive peat lands proposed to be drained for the production of truck crops. The plan excluded from drainage large tracts of tamarack swamp and leather-leaf bog; unique types of habitat having ecological and aesthetic value. It is rather ironical that this project which was almost purely drainage in nature originally but which was modified to preserve wildlife habitat has since been the scene of a highway relocation by the State Highway Department. A large swath of the habitat proposed for preservation under the Watershed Protection Project has since been destroyed.

So far most of the projects I have mentioned have been beneficial to wildlife as a result of the addition of wildlife features, some of which were cost-shared. Aber, es ist nicht alles geld was glänzt! Yes—all that glitters is not gold! The language is different, but the meaning is the same. We, as a Nation, should not be lulled into a false sense of security by tallying up benefits, either incidental or intangible, to the extent that we overlook some very real losses!

It should be pointed out at this time that Final Work Plans have never been completed on the real controversial watershed projects in our Region. Thus the statistics on these proposed projects do not appear as part of the foregoing Table.

It is generally in connection with agricultural water management that wildlife conservation agencies find themselves at odds with the Watershed Program. It is here that proposals for large-scale drainage of wildlife habitat become evident.

A project of great concern is the Ten Mile Creek Watershed in Lac Qui Parle and Yellow Medicine Counties, Minnesota. The watershed has a drainage area of 59,826 acres (92.5 square miles). Its topography is flat to gently rolling open prairie lands, pock-marked with numerous small wetlands or potholes providing good wildlife habitat.

Ten Mile Creek has been realigned and ditched throughout most of its length. Since some of the original channel work was accomplished in 1904, many miles of additional lateral and sublateral ditches have been connected to the Creek. In the last 30 years ditches and title drains have contributed to extensive destruction of wetlands. Lack of maintenance, however, has permitted willows and other plant growth as well as siltation to clog the drainage outlets. Thus, at least for the present, the inefficiencies of the outlets have saved the remaining wetlands from drainage.

There are between 6,000 and 7,000 wetlands and about 1,000 acres of timber and brush in the Ten Mile Watershed. The Bureau of Sport Fisheries and Wildlife contends that the wildlife habitat remaining in the watershed is more valuable (not better) today than it was 50 years ago.

Ten to fifteen thousand ducks, mostly mallards, have been observed in the Ten Mile area during years of good water distribution. During such years it is estimated that successful nesting and brood production in the watershed add about 10,000 ducks to the continental population.

The Bureau of Sport Fisheries and Wildlife and the Minnesota Conservation Department have studied a number of plans directed toward the preservation of wildlife values of the watershed of Ten Mile Creek. In each instance drainage features appeared to cancel out any benefits to wildlife. Since wetland areas in the watershed are uniformly distributed and heavily utilized by wildlife, it may be impossible to come up with a plan which would permit extensive drainage and still retain the vital and essential wildlife habitat.

Another watershed, namely Stoney Run, draining about 52 square miles in Yellow Medicine County, Minnesota, presented problems similar to those of Ten Mile Creek. In this instance 60 per cent of the watershed soils needed drainage. Because of the stand taken by the Department of the Interior and the Minnesota Conservation Department on Ten Mile Creek, local interests, while interested in seeking assistance under P. L. 566, decided at the outset to go the Judicial Ditch route. The project is completed and wildlife is the loser.

A third project involving valuable wetland habitat, namely Crane Creek Watershed in Steele and Waseca Counties, Minnesota, has been under consideration for some time. Located in what was once excellent waterfowl habitat, the area is still considered among the better areas of the State for both waterfowl and pheasants.

The primary features of the project include increasing the channel capacity of Crane Creek and the improvement of some of the existing major outlet ditches. It is another case where drainage is of primary concern and our Bureau and the Minnesota Conservation Department have met with agricultural interests on numerous occasions in an attempt to find a solution to the problem.

Some headway has been made, largely by negotiation and compromise, in gaining acceptance of certain key wildlife proposals by project sponsors. Excellent cooperation from the Soil Conservation Service in attempts of Conservation Agencies to arrive at an acceptable plan appear to have salvaged some benefits for wildlife. Latest indications are that work plans might offset some of the losses to wildlife that will occur as the result of the project.

The foregoing discussions indicate that the Watershed Program is a source of mixed blessings for fish and wildlife. Where projects are planned on a truly multiple-purpose basis, fish and wildlife stand to benefit; however, if these resources are to reap the greatest benefits from the Watershed Program, full use should be made of the cost-sharing provisions of the amended Watershed Protection and Flood Prevention Act. There appear to be golden opportunities for the States, in particular, to obtain fish and wildlife facilities at bargain prices if they are willing and able to avail themselves of the oportunities.

Also, additional emphasis should be placed on the installation of land-treatment measures other than the drainage of wetlands valuable to wildlife. Though often more difficult to achieve and to recognize as compared to the installation of structural measures, land treatment is nonetheless important and in certain cases may be critical to the success of providing benefits to wildlife.

And finally, our liaison between planning agencies must be stepped up. Both President Kennedy and Secretary of the Interior Udall have, on numerous occasions, expressed the need for improving coordination between such agencies particularly with respect to resolving the wetlands drainage problem.

If results of the Small Watershed Program are to be truly multipurpose the planning for the program must likewise be truly comprehensive. As Thomas Jefferson once said ''Let us, fellow citizens, unite with one heart and one mind . . . Every difference of opinion is not a difference of principle.''

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WILDLIFE USAGE AND MOSQUITO PRODUCTION ON IMPOUNDED TIDAL MARSHES IN DELAWARE, 1956-1962[1, 2]

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In Delaware, efforts to improve tidal salt marshes for wildlife conservation entered the field of marsh management years after extensive mosquito control ditching activities were well established (MacNamara, 1952). Ditching produced gross changes in tidal marsh habitat resulting in conspicuous decrease in usage of such areas by wildlife (Bourn and Cottam, 1950). Recently, impoundment of tidal marshes producing colateral selective mosquito control and improvement of waterfowl habitat has gained favor as an alternate method of tideland management (Provost, 1959). Through the cooperation of the Delaware Board of Game and Fish Commissioners, the Mosquito Control Division of the Delaware State Highway Department, and the Department of Entomology, University of Delaware long term studies were made on mosquito control and wildlife conservation values of impounded tidal salt marshes from 1956 through 1962. Field observations and short term analyses from these studies have been reported, in part, in a series of Master's theses (Catts, 1957; Florschutz, 1959; Tindall, 1961 and Lesser, 1963). The purpose of this paper is to correlate these findings and to discuss what appears to be the more important features influencing successful salt marsh impoundment. A total of five impounded marshes varying in size from 85 to 348 acres were evaluated as to mosquito production and wildlife usage. Four of these marshes, totaling 737 acres and located at the Little Creek Wildlife Area, were studied through the first three years following impoundment and one marsh, of 85 acres located on the Assawoman Wildlife Area, was studied from the fourth to sixth years of impoundment.

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[2]Financed by Delaware Board of Game and Fish Commissioners.
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During each season, mosquito production and wildlife usage of the impoundments were compared against unimpounded marshes adjacent to the flooded marshes. Impoundment margins were formed either by low earthen road-dikes or by natural high ground, and maximal marsh water depth was limited by means of a sluice gate. No other water-level-control devices were used in these studies. Initial flooding was accomplished by tidal inundation, and water levels were replenished fortuitously by storm tides and by rain and fresh water run-off from high ground adjacent to each impoundment.

METHODS AND MATERIALS

The techniques, used throughout these investigations and described in the Master's theses referred to above, were kept as uniform as possible over the entire 7 year period of study.

Numbers of mosquito larvae and pupae collected by surface dipping at series of permanent collecting stations were considered to be an indicator of mosquito production in the sampled area. There were from 10-25 such stations located in representative vegetational cover of each marsh. Weekly, from April through October, ten dips were taken within a 20-foot radius of the station marking stake. Depth, temperature, hydrogen ion concentration, and salinity of water and type of habitat were recorded at each station. Within one mile of the impoundments, a New Jersey-type mosquito light trap sampled adult mosquitoes nocturnally active in the surrounding country. Impoundments were cover typed through coordinated use of aerial photographs and ground reconnaissance. Observational census of wildlife in and over the impoundments emphasized usage and production by waterbirds.

FINDINGS

Through these studies, there was no control over water depth once it receded from maximal level. However, all impoundments were observed at various depths and presented an array of interrelationships between marsh, water depth, mosquitoes, and wildlife. A conspicuous, consistent change in mosquito fauna followed impoundment. This change, illustrated as the percent occurrence of mosquito genera and the total mosquitoes per dip in impounded and unimpounded marshes, is given in Table 1. In unimpounded marshes, *Aedes* mosquitoes dominated the mosquito fauna collected. During 1958, a season of heavy rainfall and high tides, the proportion of *Aedes* mosquitoes decreased as a result of semi-permanent flooding in areas of unimpounded marsh. ***Aedes sollicitans,*** the principal

TABLE 1. PERCENT OCCURRENCE OF MOSQUITO GENERA AND TOTAL NUMBERS OF MOSQUITOES PER DIP AT POSITIVE COLLECTION STATIONS IN UNIMPOUNDED AND IMPOUNDED SALT MARSHES, FROM JUNE THROUGH SEPTEMBER, 1956-1962

	Unimpounded marsh				Impounded marsh			
	% occurrence of mosquito genera			Mosquitoes per dip	% occurrence of mosquito genera			Mosquitoes per dip
Season	Aedes	Culex	Other		Aedes	Culex	Other	
1956	91	4	5	3.0	1	89	10	2.1
1957	92	4	4	7.1	9	88	3	2.7
1958	76	17	7	3.2	1	99	0	3.2
1959	96	4	0	24.9	—	—	—	—
1960	—	—	—	—	0	93	7	4.4
1961	—	—	—	—	1	96	3	6.5
1962	—	—	—	—	46	52	2	10.4

species collected (*circa* 93% of all *Aedes* spp.) is considered the major pest mosquito in Central Atlantic coastal areas.

In all impounded marshes *Culex* mosquitoes were collected most often and *C. salinarius* (*circa* 97% of all *Culex* spp.), was the principal species present. In 1962, a very dry season, marsh water levels dropped below the general level of the marsh floor and, upon reflooding, a large proportion of the mosquitoes dipped were *A. sollicitans*, This shows that following 3 years of flooding, the area still was a suitable oviposition site for *A. sollicitans* after the marsh floor had been exposed by dropping water levels. Other *Aedes* mosquitoes produced on impounded marshes occurred in the spring (*i.e. A. canadensis* and *A. cantator*) and were not considered important because of their low numbers and early appearance. Fluctuations in marsh water salinity (0.1 o/oo to 33 o/oo) mirrored changes in impounded water level and had no apparent influence on prevalent mosquito fauna.

Most mosquitoes were associated with stands of salt hay (*Spartina patens* and *Distichlis spicata*) and of salt marsh cord grass (*S. alterniflora*). In impoundments *C. salinarius* was essentially limited to emergent stands of these plants at certain water depths. Characteristically *A. sollicitans* produced in unimpounded marshes also was associated with salt hay. In these tidal marshes, salt hay is the principal vegetational cover present and is flooded only periodically following high tides or heavy rains. After impoundment, large areas of salt hay were no longer potential mosquito producing areas. As a result of permanent flooding, *A. sollicitans* was eliminated. Apparently as a result of habitat changes, related to water depth, *C. salinarius* was restricted to limited areas. Although stands of salt hay along impoundment margins were suitable habitat for *C. salinarius*, the total acreage of this habitat was reduced greatly after flooding.

Occurrence and density of impoundment mosquitoes appears relat-

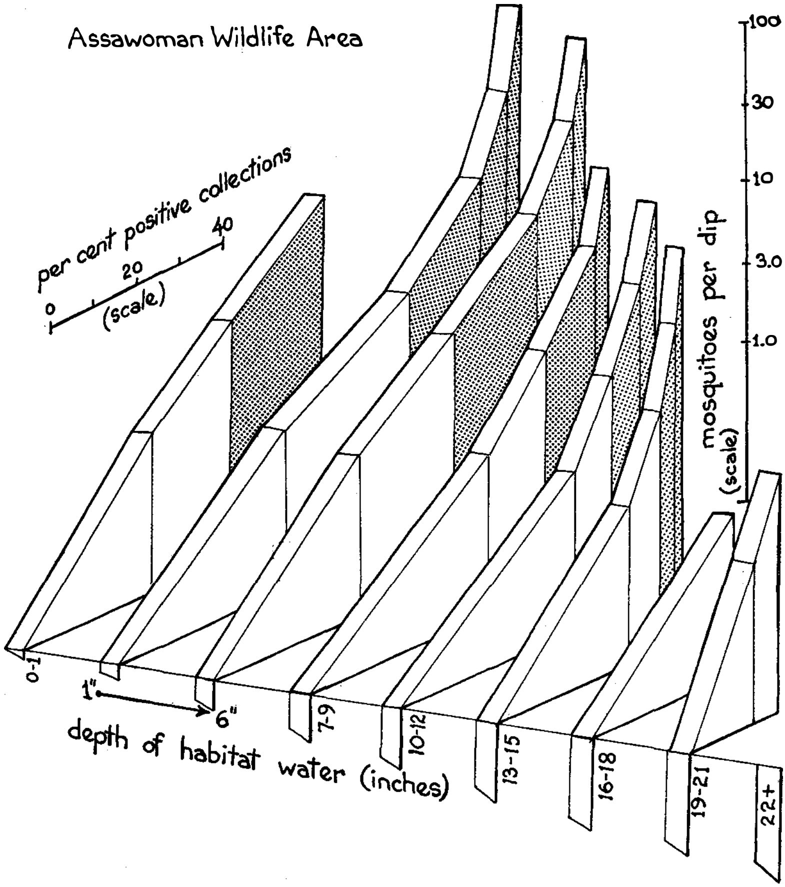

Figure 1A. Percent positive occurrence and number of mosquito larvae and pupae (per dip) collected in various habitat water depths at the Assawoman impoundment, 1956-1958 (shaded portions indicate more than 3.0 mosquitoes per dip).

ed to water depth. The percent of positive collections and the numbers of mosquitoes per dip collected at various habitat water depths are illustrated diagrammatically in Figure 1A, for the Assawoman impoundment, and in Figure 1B for all four Little Creek impoundments. The period covered by these data is from June through September for three seasons on each area. Mosquitoes occurred most often and in greatest numbers in 1-6 inches of water.

There was conspicuous increase in wildlife usage of marshes after impoundment. The following counts represent numbers of water birds/100 acres/day from April through October during 1961 and 1962

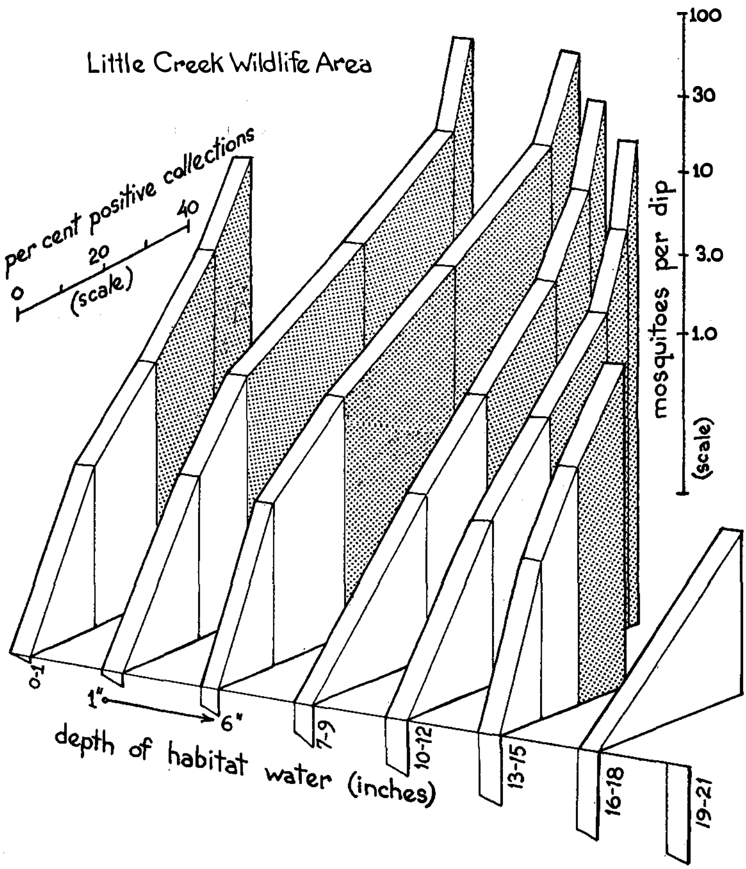

Figure 1B. Percent positive occurence and number of mosquito larvae and pupae (per dip) collected in various habitat water depths at four Little Creek impoundments, 1961-1962 (shaded portions indicate more than 3.0 mosquitoes per dip)

respectively on all four Little Creek impoundments: Grebes, 3.0 and 1.6; Waders, 71.3 and 34.1; Geese, 13.4 and 24.2; Puddle ducks, 263.5 and 118.7; Diving ducks, 2.2 and 1.9; Rails, 17.7 and 8.2; Shorebirds, 47.1 and 191.2; and Gulls and Terns, 20.3 and 29.6. Lower counts in 1962 for all groups except shorebirds reflects a general, drastic decrease in marsh water level on all impoundments during that season. The total number of waterbird species observed at Little Creek one year prior to impoundment and three years after impoundment is 23 and 94 respectively.

In 1959, the year prior to impoundment, no duck broods were seen at Little Creek. In contrast, total Puddle duck counts, breeding

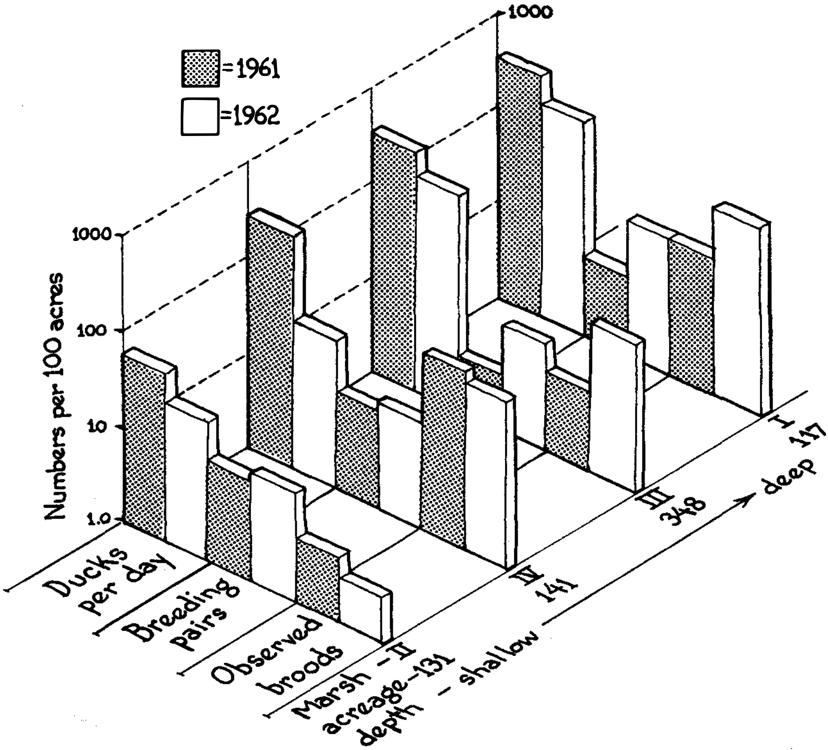

Figure 2. Observed Puddle duck usage of four impounded marshes at Little Creek, Delaware from April through October, 1961 and 1962.

pair counts and total brood counts for these same marshes are shown in Figure 2 for 1961 and 1962. The breeding pair counts, begun early in May, do not include black ducks and mallards as many of these species pair and estrange earlier in the year. However, brood counts included both of these species.

In 1962, during the course of six drives at weekly intervals, over the same impoundment, 451 ducklings were banded and released, and 25 per cent of these were recaptured. Subtraction of this percent recapture from the total number of ducklings counted (2339) at Little Creek indicates production of approximately 2.4 ducks per acre in 1962.

The acreage and density of emergent vegetation was directly affected by marsh water level. Observations on the Little Creek impoundments indicated a general concentration of resident duck populations in areas having moderate water depth and a high degree of interspersed emergent vegetation. This bird concentration is less apparent in Figure 2 because marsh water levels varied considerably during both seasons resulting in constant shifting of resident duck populations over all impoundments. Although broad, deep, unbroken areas of water were attractive to migrating water birds (especially geese) such areas were utilized much less by resident birds during breeding season.

DISCUSSION

Impoundment water depth appears to be the principal influencing factor on mosquito and wildlife incidence. The prevalent impoundment mosquito, *C. salinarius*, was concentrated in emergent vegetation, principally salt hay, flooded to depths of 6 inches or less. Recent unpublished experiments by Murphey (1963) show an oviposition preference by gravid *C. salinarius* females for infusion-like stands of grasses and straw. This infusion habitat may not occur where emergent vegetation is in deeper water, or perhaps in deeper water there is a closer balance between mosquitoes as prey populations and mosquito predator efficiency. In marginal salt hay areas flooded by water depths of 10 inches or more mosquito counts consistently were low. Changes in marsh mosquito fauna following impoundment generally agrees with findings of other impoundment studies (Chapman and Ferrigno, 1956; Darsie and Springer, 1957; Provost, 1959).

Conclusions with respect to marsh water depths optimal for waterbird usage still are speculative and need further study. However, observations on the four Little Creek marshes over three seasons strongly indicate the desirability of moderate to shallow water depths to provide a high degree of plant-water interspersion or juxtaposition. A general water depth of 9-12 inches appears compatible with gradual plant interspersion and limitation of mosquito populations. This agrees with suggested water levels proposed by Provost (1959). Impoundment duck production of 2.4 birds per acre in 1962 compares favorably to yields reported from areas considered to be excellent duck breeding habitat (Bear, 1953; Keith, 1961).

Beneficial effects of plant-water interspersion have been indicated by others (Steenis and Warren, 1959; Steenis, et al., 1959; Beard, 1953). Interspersed emergent vegetation provides not only protective cover for waterbirds, but also aquatic entry into foraging areas which otherwise might be comparatively inaccessible. Diet of young mallard ducklings principally consists of aquatic and terrestrial fauna (Chura, 1961) which generally tends to concentrate, during the daytime at least, in interspersed emergent vegetation.

In several areas of Little Creek impoundments, plant-water interspersion progressed more rapidly in stands of vegetation which had been crossed repeatedly with a tracked amphibious vehicle. This suggests a nonchemical method of promoting desirable interspersion.

SUMMARY

Long term studies evaluating the effects of salt marsh impounding on mosquito production and wildlife usage in Delaware indicate marsh water level as the important factor involved.

Moderate water levels of 9-12 inches in depth are compatible both with low mosquito production and high waterbird usage. After flooding, immature stages of pestiferous *Aedes* mosquitoes, common to unimpounded marshes, were replaced by *Culex* species. These *Culex* mosquitoes occurred most often and in greatest numbers at water depths of from 1-6 inches.

Waterbird usages of marshes was increased conspicuously following impoundment. In marshes having moderate water depths, a higher degree of plant-water interspersion appeared to favor resident ducks and brood production. However, in deeper impoundments having large areas of open water, most usage was by migratory waterbirds.

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RESTORATION OF BREEDING CANADA GOOSE FLOCKS IN THE NORTH CENTRAL STATES

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The maintenance of waterfowl habitat and waterfowl populations in the desired variety, size and location is one of the most critical factors facing waterfowl biologists and administrators today. The annual loss of waterfowl production habitat in the presence of increased demands for hunting and other recreational pursuits dictates that greater emphasis be given to increasing the productive capacity of managed private and public areas to partially compensate for these losses. One important contribution toward attainment of this goal has been the establishment or restoration of breeding populations of Canada geese, *Branta canadensis,* on federal refuges and state management areas. The primary objective is to re-establish a native species within its original breeding range for scientific and esthetic purposes, with a view toward eventually contributing to local hunting opportunity.

Captive flocks of Canada geese have been maintained on many national wildlife refuges and several state waterfowl management areas in the North Central States since the middle 1930's. Small groups of geese were initially introduced to serve as decoy flocks to attract migrants and to aid in dispersal of migratory and wintering populations. Several national wildlife refuges were also selected for experimental releases in 1935-1936 in an attempt to re-establish breeding populations of Canada geese.

Similar release programs were started by the Michigan Department of Conservation on State wildlife areas about 1930. The Minnesota, Wisconsin, Ohio, and Missouri departments have started local breeding flocks during the past five to ten years.

These early introductions or reintroductions experienced varying degrees of success. Decoy flocks generally served their purposes well and were abandoned as soon as the pattern of goose use for the area increased to a desirable level. Some nesting occurred but was negligible since geese used were from a variety of sources, largely pinioned and crippled birds which did not exhibit breeding tendencies. Some voluntary additions to refuge breeding flocks resulted from natural replacement by wild, free-flying birds or by mating with captives, the progeny of which then returned to breed on the refuge.

The successes and failures of planned introductions to establish breeding population on national wildlife refuges are discussed in further detail on the basis of operations carried out under Phases I-III of the program. Phase I covered the period 1936-1955, using various sources of breeding stock. Phase II was carried out from 1956-1960 using birds-of-the-year held on areas for three years prior to release. Phase III, a modification of Phase II, was started in 1960 using mated pairs or preflight goslings from established local breeding flocks or carefully selected semidomestic stock. An analysis of accomplishments to date, principal problems encountered and recommendations for future programs are presented. The principal areas involved are shown in Figure 1.

MANAGEMENT PRACTICES AND RESULTS

Phase I. The first attempt to establish a major breeding flock on a national wildlife refuge was at the Seney Refuge in northern

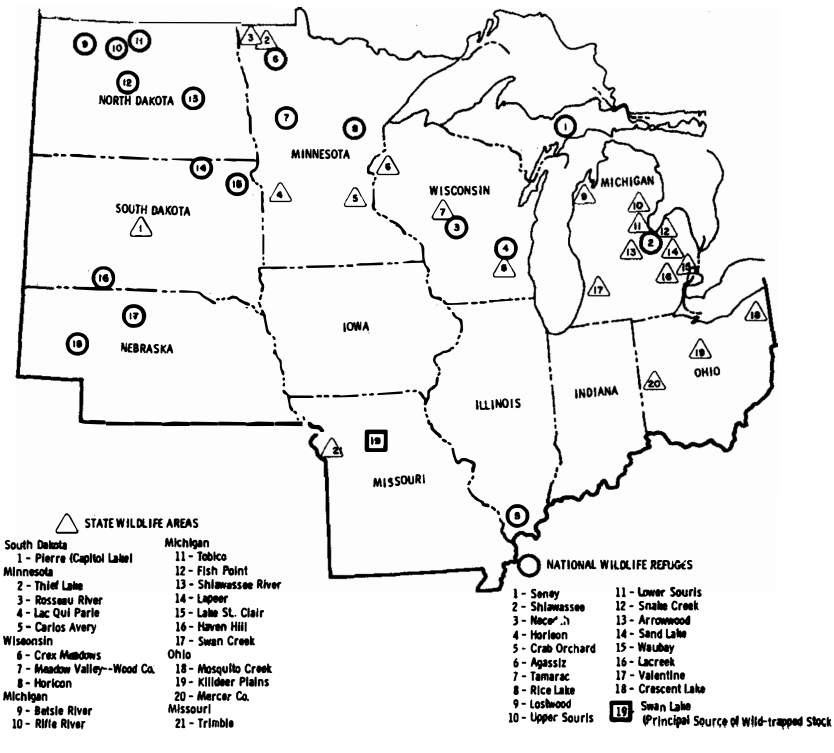

Figure 1. National Wildlife Refuges and State Wildlife Areas Engaged in Canada Goose Restoration Programs

Michigan in 1936, when 330 geese were received from Mr. Henry Wallace of Howell, Michigan. These birds were of semidomestic origin and were descendants from four pairs of geese obtained from a goose breeder at Owatonna, Minnesota, in 1924. This original plant of Seney geese consisted largely of pinioned birds held in a large enclosure where nesting occurred. During subsequent years mated pairs and goslings were allowed to remain full-winged. They returned to the wild and the local breeding flock gradually increased.

In 1937 a similar program was started at the Lower Souris Refuge in North Dakota, using 22 hand-reared goslings of *B. c moffitti*, hatched from eggs obtained at the Malheur Refuge in Oregon. Similar releases were made at the Sand Lake Refuge, South Dakota; Agassiz Refuge, Minnesota; Crescent Lake Refuge, Nebraska; Necedah Refuge, Wisconsin, and Upper Souris Refuge, North Dakota, using breeding stock of the same subspecies obtained from wild flocks at the Bear River Refuge in Utah or the Bowdoin Refuge in Montana. The flock at the Waubay Refuge in South Dakota was also started at that time using stock from a local game breeder.

Beginning about 1947 additional geese from a variety of sources were used to revive the decoy flock concept and to establish breeding populations. The restoration program expanded during the early 1950's until about 15 refuges in the North Central States were experimenting with establishment of breeding flocks.

A summary of the success of early efforts to re-establish breeding populations of Canada geese on refuges in the North Central Region is given in Table 1. Only five of a dozen or so refuges in Region 3 which participated in early goose transplant efforts now have established thriving breeding flocks. The Seney Refuge is the most noteworthy, with an annual production of 800-1,000 goslings; Lower Souris follows with an average of 150-200; Sand Lake has averaged 70-100; Agassiz now produces 100-150; and Waubay has fluctuated between 50-160. It is encouraging to note that geese are beginning to spread out to nest in marshes and lakes surrounding Seney, Waubay and Agassiz Refuges. A total of approximately 22,300 geese has been raised from these established goose flocks during the 26-year period, 1936-62, 60 per cent of which were produced at Seney and 12 per cent at Lower Souris. With the exception of the good success at Seney and Lower Souris, and the limited results at Sand Lake, Agassiz, Upper Souris and Waubay to date, the program was disappointing.

Phase II. Because of the many different procedures and varied sources of breeding stock employed in attempting to restore breeding populations, it was determined in 1956 that a more systematic

TABLE 1. PRODUCTION BY CANADA GOOSE FLOCKS ON REGION 3 REFUGES
1936-62

Refuge	Project Age (Years)	Source of Parent Stock	Total Production	Ave. Annual Production 1958-62	Free-flying Flock 1961-62[4]
Agassiz (Mud Lake)[1]	23	Seney Refuge Prs. & goslings.	1,090	150	550
Crab Orchard[2]	14	Goslings from decoy flock — cripples (P)	90	20	30
Crescent Lake[1]	13	Bear River Refuge (P), Swan Lake Refuge (B) North Platte, Neb. (SD)	300	40	300
Lower Souris[1]	25	Eggs from Malheur Refuge; hand reared goslings	2,800	140	300[5]
Lacreek	9	Swan Lake Refuge; North Platte, Neb. (SD)	0	0	150
Necedah[1]	23	Bear River Refuge (P)	650	50	200
Rice Lake	11	Decoy flock — cripples from Horicon (WC), Seney goslings and SD.	180	30	80
Sand Lake[1]	23	Bear River Refuge (P)	1,340	70	250
Seney[1]	26	Private breeder — Mich. (SD)	13,345	780	1,200
Shiawassee	4	Michigan Game Farm (SD and Seney descendants)	375	95[3]	400
Tamarac	10	Bowdoin, Sand Lake and Swan Lake Refuges. SD from N.D. and Wis. breeders.	210	35	155
Upper Souris[1]	23	Waubay, Bowdoin, Sand Lake and Swan Lake Refuges. Initial succes by Waubay birds.	730	90	250
Waubay[1]	25	Local private breeders. (SD)	1,185	50	200
	TOTAL PRODUCTION		22,295	1,550	4,065

P — Pinioned WC — Wing-clipped B — Brailed SD — Semidomestic

[1]No longer have captive flocks, except for experimental purposes at Agassiz, Crescent Lake, and Lower Souris. Free-flying breeding flocks established.

[2]No active management for nesting geese, small breeding flock remaining.

[3]Produced 25—1960, 125—1961, 225—1962. Continuation dependent upon survival and migratory tendencies of present flock.

[4]Prior to arrival of fall migrants.

[5]Sharp decline 1961-62 because of high nest loss due to predation and climatic factors.

procedure should be implemented for restoration of breeding goose flocks on national wildlife refuges. The detailed procedures for controlled releases were set forth in a bulletin, ''The Restoration of Breeding Canada Goose Populations on National Wildlife Refuges,'' Wildlife Management Leaflet No. 15, which was published by the Fish and Wildlife Service in 1958.

Basically, the new procedure provided that the management of captive flocks for eventual propagation purposes on national wildlife refuges would be carried out only on those areas meeting specific qualifications. Transplant stock was to consist exclusively of birds-of-the-year obtained as goslings from established breeding populations, such as the Seney flock, or ''notch-tail'' immatures captured during their southward migration as early in the fall as possible. Sex and age determination was based on plumage and cloacal characteristics cited by (Elder, 1946) and (Hanson, 1949). These birds were to be kept flightless through the third winter after their capture and then released as free-flyers.

The preferred use of goslings was based on the premise that, if the young birds were not firmly imprinted to their natal area, they would adopt new surroundings readily. It was likewise assumed that birds-of-the-year trapped during their first migration had not strengthened their attachment to specific breeding areas or migration routes and that they would accept new areas.

While there is a difference of opinion among authorities as to the age wild Canada geese commence nesting, it was generally agreed that most of them nest toward the end of their third year of life, and that release schedules should be planned accordingly. It was realized that some might breed toward the end of their second year of life, but all were held until the third year to reduce loss to hunting until most of them were ready to nest. Hanson(1962) has since suggested that while the actual percentage of two-year old females that nest in the wild is not known, it may be significant number, at least for *B.c. interior.*

During the period of 1956-1962, eleven national wildlife refuges in the North Central Region were participating in the controlled release program (Table 2). Three other refuges (Seney, Lower Souris, Wauby) had well established breeding populations. All geese released under this program were marked with colored plastic leg bands under an approved color arrangement schedule to permit identification of a specific age class from each release site.

Most of the birds used in Phase II were obtained as goslings at Seney Refuge or as immature birds trapped during the fall migration at the Swan Lake Refuge in Missouri. In addition, a limited number

TABLE 2. PRESENT STATUS OF PROGRAM FOR RESTORATION OF BREEDING CANADA GOOSE FLOCKS USING BIRDS-OF-THE-YEAR—REGION 3 REFUGES

Refuge	1956	1957	1958	1959	1960	1961	Releases 1959	Releases 1960	Releases 1961	Releases 1962	Birds on Hand	Results
Agassiz	—	40 (28) SL	42 (7) SL	41 (31) SL	36 (36) SL,SD	—	—	25	—	36 41[1]	0	Breeding flock established from Seney prs. and goslings.
Arrowwood	—	40 (0) SL	40 (0) SL	41 (23) SL	—	—	—	0	0	23	0	None.
Crescent Lake	36 (9) SL	43 (38) SL	42 (37) SL	45 (31) SL	—	—	9	38	37	—	31[1]	Breeding flock established from old Bear River birds, 2nd gen. breeding in wild now.
Lacreek	40 (0) SL	40 (31) SL	41 (8) SL	43 (16) SL	50 (0) SL	54 (27) SD	0	31	8	16	27	None.
Lostwood	28 (3) LS	40 (8) SL	39 (17) S	41 (23) SL	—	35 (27) SD	—	8	17	23	30	Three broods 1961 from Seney goslings.
Rice Lake	—	13 (0) S	40 (29) S,SL	40 (29) S	48 (42) SL,SD	49 (45)	—	35	28	29	119[1]	Limited reproduction from old pinioned flock. Six broods 1961 from Seney goslings.
Shiawassee	—	—	—	200 (190) SD	97 (81) SD	100 (90) SD	40	150	81	90	120[2]	Produced 225 goslings in 1962. Flock left area winter 1963 for first time.
Snake Creek	65 (1) SL	40 (0) SL	40 (0) S	32 (24) SD	—	35 (30) SD	—	—	14	44	34[3]	Four broods in pen, 1 in wild, 1960-62 from SD.
Tamarac	—	—	40 (8) SL	65 (60) SL,SD	40 (34) SL	36 (35) SD	—	—	8	31	98	Early reproduction probably from Bowdoin birds. Recent nesting by SD.
Upper Souris	—	40 (14) SL	40 (14) SL	42 (17) SL	—	—	—	14	14	17	0	Breeding flock apparently resulted from Waubay goslings received in 1940 and offspring.
Valentine	40 (10) SL	40 (0) SL	41 (0) SL	45 (27) SL	—	—	10	0	0	27	25[2]	Limited reproduction, probably from SD release 1950-51.
Totals	209 (23)	336 (119)	405 (120)	635 (471)	271 (193)	309 (254)	59	301	207	377	484	
GRAND TOTAL				2,165 / (1,180) Survival Rate—54.5%				(944)			(484)	

40—Number received. (0)—Number surviving. S—origin (S—Seney Refuge, SL—Swan Lake Refuge, LS—Lower Souris, SD—semidomestic from state flocks or game breeders).

[1]Includes some previously pinioned birds and others held for penned breeding purposes—goslings being released.

[2]Semidomestic stock obtained in 1962 to be released as scheduled.

[3]Portion of release returned to remainder of semidomestics breeding in pen.

of wild goslings raised at Lower Souris Refuge were captured and held for later release and other experimental work there. There were also opportunities to obtain illegally held semidomestic goslings and mated pairs from private captive goose flocks confiscated by the Branch of Management and Enforcement.

Releases were made in Phase II of the program as shown in Table 2. Results have been largely negative, except at Shiawassee where semidomestic geese were used. During the time Phase II was being implemented, breeding flocks had become established at Agassiz, Crescent Lake and Upper Souris Refuges, so transplanting was stopped on these areas in 1959.

In reviewing survival records from Phase II operations, we find that 2,165 geese used during the seven-year period, about 1,180 or 55 per cent were actually retained for release as scheduled. Approximately 18 per cent of the total escaped to the wild; the remainder lost to predation and natural mortality. Subsequent observations and analysis of band recovery data revealed that in only a few instances did successful breeding occur among geese from Swan Lake stock. Where mating and nesting did occur, it was in the pens, generally between captive females and ganders attracted from the wild or mixed matings between wild stock being held in pens and semidomestic stock.

There is no conclusive proof that notch-tailed females trapped at Swan Lake Refuge and held for the three-year period became productive in the wild on the areas on which they were released.

In most instances birds trapped at Swan Lake, moved to new locations and eventually released during early spring, stayed around until the majority of spring migrants passed through and then disappeared. A number of band recoveries were reported the first fall or subsequent years from the Swan Lake vicinity or southern Illinois, *regardless of where they were released.* In other instances, a number of the geese have remained through the first summer or as a wintering flock for a year or two. The eventual fate of these groups remains to be learned.

There has been some recent evidence of nesting success, however, at the Rice Lake Refuge (Minnesota) and the Lostwood Refuge (North Dakota) where goslings from Seney were released under the controlled program, and at the Tamarac Refuge (Minnesota) where mated pairs and goslings from semidomestic stock were used (Table 2).

Phase III. It became evident by 1960, after the second series of releases under Phase II, that this approach needed to be re-evaluated, and a final decision made on the merits of this program by the end of 1962. Based on successful use of Seney goslings and the adaptability of semidomestic stock as demonstrated at Waubay, changes in certain Phase II procedures were in order. It was generally agreed that wherever additional introductions were planned on national wildlife refuges first priority should be given to use of preflight goslings or mated pairs from established local breeding populations, and second priority to use of goslings or mated pairs from semidomestic stock, to be obtained insofar as possible from selected aviculturists whose stock was known to coincide with the former breeding range represented by the refuge selected for the release. It is still too early to determine the results of additional transplanting done under the revised program.

The largest transplant of the latter type has been at the Shiawassee Refuge in Michigan, using two-year-old birds from the Michigan Game Farm. The geese were held in captivity and released on the project near the end of their third year of life. Some pairing of two year-old birds occurred within the pen and immediate nesting occurred by three-year-old birds in the wild. During the period 1959-62 approximately 360 geese were released at Shiawassee. In 1962 there were an estimated 60 pairs nesting within the project which produced 225 goslings. This was supplemented by additional geese released on the adjacent Shiawassee River State Game Area which may have also produced some goslings. The chief problem to date is that descendants of this flock refused to migrate until January 1963 when the entire flock left for several weeks. Further evidence on migrational behavior of these birds is needed before the significance of the Shiawassee experiment can be evaluated. Present plans are to stop additional transplanting after 1963 for two years, while the natural development and behavior of this flock are closely studied.

State Programs. While Michigan has been experimenting with releases since 1928 and Minnesota has raised geese in captivity for several years, major emphasis on restoration of local breeding populations on State projects in the North Central Area did not gain momentum until about 1957. Most of the breeding stock came from local game breeders or state game farms. There have been instances where aviculturists maintained sizable populations, some of which frequently escaped or were released into the wild and aided in establishing small wild breeding populations. At the close of 1962, the following number of major state-managed goose breeding projects were in operation: Michigan—8, Minnesota—4, Wisconsin—4, Ohio—3, South Dakota—1, and Missouri—1.

Based on information provided by State Game and Fish Departments, Canada goose production on state projects cited during the past five years was about 6,000, with 2,600 goslings raised in 1962. The expanded release program in Minnesota is just getting underway (R. L. Jessen, pers. comm. 2/4/63). In Wisconsin a captive flock at the Crex Meadows project is producing free-flying young. Small breeding flocks are established at three other state areas, with average annual production for all areas now ranging from 300-350 goslings (R. A. Hunt, pers. comm. 2/20/63). The production in Ohio in 1962 was 1,045 goslings (K. E. Bednarik, pers. comm. 2/3/63). In Michigan an estimated 1,000-1,200 goslings were produced in 1962, exclusive of Shiawassee (M. L. Petoskey, pers. comm. 2/1/63). There has also been good success experienced at the Trimble Wildlife Area in Missouri as reported by Vaught (1960), and Brakhage (1962), with 196 goslings hatched in 1962.

As near as can be determined, progeny of the Minnesota and Missouri flocks have shown little or no migratory tendencies; geese produced in Ohio have migrated to only a slight degree; while in Wisconsin and Michigan most of the locally raised geese are forced to migrate. In Wisconsin, Michigan, and Ohio, there is evidence of locally established breeding populations spreading into surrounding countryside where suitable nesting habitat is present.

MANAGEMENT IMPLICATIONS

Source of breeding stock. From experiences in the North Central States, it is particularly important to consider the source of birds used in the transplant attempts. Consideration should also be given to the physiological, psychological and genetic factors influencing adaptation to new habitats. This is especially true in the case of wild birds which are trapped in migration and of mixed groupings of various sex and age classes of pinioned and crippled birds.

Breeding stock used in Phase I came from several sources as indicated, principally *Branta canadensis moffitti,* from Bear River, Malheur, and Bowdoin Refuges and what was long believed to be *B. c. interior* from the Seney Refuge (Aldrich, 1946, 1957). It has been suspected for some time that certain aviculturists have perpetuated strains of the giant Canada goose, *B. c. maxima* and that such blood lines were present in the Waubay and Seney flocks. Recent investigations by Harold Hanson, as described by *Time* Magazine (Canada), September 21, 1962, appear to substantiate the presence of this race in the Midwest (Hanson, 1962). Further investigations by Hanson and the writer have indicated that perhaps most of the successfully established local breeding flocks on national wildlife refuges, state projects and several private areas in the Midwest resulted from releases of direct descendants of the giant Canada goose, long believed to have been extinct according to Delacour (1954). Hanson will present the details of this discovery in a forthcoming publication, which should have a significant impact on future transplanting programs in the North Central States.

It is now apparent that only stock from established local breeding populations should be used in transplanting programs and that further efforts should be made to perpetuate the large geese, since these birds seem to be well adapted to the North Central Region.

One possible reason for the success resulting from the transplanting of Seney geese, as well as other stock obtained from game breeders, is suggested. These larger, hardier birds originally adapted to the Great Plains, appear to be more tolerant of cold weather during early spring and late fall, and can winter under severe conditions if necessary. By the same token, *B. c. interior,* a bird of the Hudson Bay lowlands and interior coniferous bogs, (Hanson and Smith, 1950), may be less suited to the prairie environment. While there seems little doubt that what was assumed to be *B.c. moffitti* became established on a few areas in the Dakotas in the early days of the restoration programs, there is also the possiblity that the race *moffitti,* if indeed it was this subspecies, may have been replaced naturally by the larger race.

There are some questionable features about certain procedures in Phase II. It is agreed that the best source of transplanting stock is goslings from a wild breeding flock such as that at Seney Refuge. We can, however, take only a limited number of goslings there each year if we manage on the basis of maintaining an increasing flock, unless better control over kill can be achieved on migration and wintering areas used by this flock. There presently is a downward trend in this breeding population and the removal of a large number of goslings would further reduce the breeding potential.

A serious question arises over the problems introduced by moving various races or subpopulations of geese out of their normal breeding and migration range into a new environment. For example, a bird-of-the-year trapped at Swan Lake in the fall may already have a firm attachment to its natal environment, immunity to diseases and parasites common to that section of the breeding grounds, a strong association with the migration route traveled, and thus may never adjust to different surroundings.

Problems were also encountered in distinguishing between individuals representing a smaller race of Canada geese from young-of-the-year of the larger Canadas, both of which use the Swan Lake Refuge. Unless selection at time of trapping is accurate, the problems associated with establishing populations outside natural breeding ranges may add further confusion to Canada goose taxonomy.

Size of initial releases. While it may be somewhat academic to reflect upon the lack of success because of the size of actual releases made of stock from the Swan Lake Refuge (*B, c. interior*), losses of birds during the two to three-year holding period resulted in relatively small numbers of a given age class being released (Table 2). It has been suggested that had units of 100-200 geese been used in each release, perhaps response may have been different. It is doubtful, however, that increasing the numbers of geese released from different adapted racial stock would have made much difference as far as the Swan Lake birds are concerned.

Sex and age composition. There is good evidence that environmentally conditioned, mated pairs would have comprised the best units of release, as in the case of the Agassiz flock which apparently resulted from release of mated pairs and goslings from Seney, but such birds are the hardest to obtain. Under Phase II, an attempt was made to obtain nearly equal sex ratios. In the event a differential existed, it was generally in favor of an excess of females as it is known that transient wild ganders will pair with captive females. The effects of releasing only females are not known however.

Availability of nesting sites. There are indications that the size of breeding populations on some refuges has been proportional to the number of nesting sites available, natural or artificial. Natural islands, one tenth to two acres in size, cleared of most trees and other woody vegetation, received priority acceptance at the Seney Refuge. At Lower Souris various sizes of artificial islands have long been accepted by the local breeding flock. Under natural conditions at Agassiz and Sand Lake the geese have made extensive use of muskrat houses, exposed points of land and dike slopes, as well as islands. At the Trimble Area in Missouri, geese are nesting successfully in wash tubs placed from two to thirty feet above the water in trees (Vaught, 1960), similar to the habits of *B. c. moffitti* which nest in haystacks, cliffs, trees and elevated artificial structures in some portions of their western range.

Thus far, geese have not nested in tubs placed in trees or high artificial stands on refuges in the Upper Midwest, but they have accepted raised nesting platforms at Waubay, Crescent Lake, Lower Souris, and Agassiz. While the selection of such unlikely nesting sites may be more a matter of conditioning than specific preference, it indicates a preference of the nesting female for a wide range of visibility.

Even though individuals of most semidomestic strains of Canada geese are initially quite tolerant of each other, and often nest fairly close together under penned conditions, there are indications that territorial demands, particularly the relative dominance status of males, influence productivity as penned and wild populations increase (Collias and Jahn, 1959). Much remains to be learned about the social behavior of Canada geese, especially the role of family dominance and general realignment of the social structure in populations as the breeding season approaches and competition for nesting sites develops (Hanson, 1953). This problem is currently being studied at the Seney Refuge where it is desirable to determine why many of the available nesting islands are not used and what the optimum distribution of nesting sites may be under habitat conditions and populations stresses there. In many areas it appears that artificial nesting platforms may be the simplest solution to providing proper distribution of the desired number of nesting sites. A detailed report on the analysis of use of various types of nesting sites is expected to shed further light on this subject.

Predation problems. Captive flocks are usually very conspicuous and are thus highly vulnerable to a variety of predation problems. Some mammalian predation and a lesser amount of avian predation were responsible for losses of captive geese in the restoration program on refuges. Control of predatory animals was generally achieved by using approved techniques, such as trapping, predator proof fences, electric fences and shocking devices and flood lights. The use of conventional traps and flood lights in the immediate vicinity of the pen proved to be the most effective.

Populations nesting in the wild are likewise subject to predation, but being unconfined, are in a better position to defend themselves and their nests. Geese nesting on islands, or platforms, generally have been less vulnerable to predation, unless emergent vegetation encroaches to the point where raccoons are encouraged to swim out. Muskrat houses also provide quite successful nesting sites, but nests on the mainland are often destroyed, particularly in areas where raccoons and foxes are common. Human disturbance kept to a minimum during the nesting period and judicious predator control have increased nesting success of captive flocks and safeguarded high density wild nesting populations on managed areas.

Some predation losses in the wild have been closely related to weather factors such as delayed spring break-up or drouth conditions which eliminated open water barriers.

Hunting pressure. Early consideration should be given to the effects of hunting on local breeding populations, particularly hunting on or in close proximity to the project during the initial years of establishing the flock. Various degrees of control over the kill of

Canada geese have been obtained by regulating the size of the sanctuary area provided, providing adequate food within protected areas, special closure of perimeter lands to Canada goose hunting and kill quota systems. In some cases it has been necessary to acquire additional key tracts of land to give the protection required. The extent to which such measures are needed depends upon local conditions and public interest. These factors apply equally well to new and older established areas when attempting to increase use by migrants or wintering populations (Nelson, 1962).

Several examples of the effects of hunting pressure in limiting flock increase can be cited. The Seney flock showed an increasing trend until about 1958, when it became apparent from band recovery data that hunting was beginning to take a heavier toll at wintering areas in southwestern Michigan and in Illinois, while the local kill showed no significant increase. At Lower Souris the local breeding flock showed a marked decrease in 1945, following a change in hunting status of the area where the flock wintered in Garden County, Nebraska. Since that time these geese have been subjected to higher annual kill which is limiting the size of the breeding flock. At Waubay there is good evidence that four nearby farms which are leased for goose hunting are harvesting a quantity approximately equal to the annual increment. Currently ways are being explored to solve these problems in cooperation with the states and Flyway Councils through the use of special area closure regulations, length of season and habitat acquisition and development programs.

Hunting may become an even more serious obstacle to establishing breeding populations in smaller marsh areas under cooperative programs with aviculturists, private landowners or sportsmen's clubs.

Other losses. A high percentage of the losses of captive birds was due to escape from pens because of faulty construction, gates being left open, or failure to clip wings at the proper time so that birds attained flight. These are practical aspects of the operation which require close attention.

There were several minor outbreaks of aspergillosis in captive goose flocks on refuges, possibly resulting from feeding baled alfalfa hay, one instance of food poisoning, believed to have been ergot poisoning, and diagnostic reports by personnel of the Patuxent Wildlife Research Center indicating possible losses of goslings from botulism, *Leucocytozoon*, and gizzard worm (*Amidostomum*) infections. Losses from exposure during prolonged periods of below-zero temperatures occurred in three flocks where there was inadequate protection from winds and blowing snow. While it was suspected that there may have been some nutritional problems, particularly with the younger birds during their first winter, no conclusive evidence was collected.

Handling techniques. When dealing with captive flocks it is important to have pen facilities that will keep the various age classes separate to reduce strife and other forms of stress induced by breeding behavior exhibited by older birds. At some refuges attempts were made to segregate age classes in widely separated pens, but this practice proved to be impractical from a management viewpoint because of predation and disturbance problems, limitations in the water supply and the daily attention required, particularly during the winter months. Much better success was experienced where pens, preferably one pen with three or more compartments, were constructed in close proximity to the refuge headquarters, but shielded from routine activities by some natural barrier, if possible. Suggestions for pen specifications are given in Wildlife Management Leaflet No. 15.

Studies of dietary problems have been continued throughout the restoration program by State and Bureau personnel. Various combinations of grains and corn, with supplemental green leafy foods, have been commonly used. There are recent indications that commercial food pellets with high protein content, fed with other supplements, provide the best diet. Further details on diets and feeding methods are presented in Wildlife Management Leaflet No. 15. This subject is discussed in more detail in current poultry journals and in, *Poultry Nutrition*, by W. R. Ewing, published by the author at South Pasadena, California, 1951.

CONCLUSIONS

The restoration of breeding flocks of Canada geese is being continued as a part of the national wildlife refuge program in the Upper Midwest. The extent to which further emphasis is given this program on refuges or waterfowl production areas in the North Central States depends upon the success of present operations, the potential of other areas for supporting a breeding population, and the ultimate utilization or esthetic values of such production. While it is evident that none of the well established flocks now makes a significant contribution to the flyway population of Canada geese, they make important local contributions in terms of esthetic value and hunting opportunity. Collectively, the state and federal areas in the North Central States are producing about 4,000-4,500 geese annually, and there is little doubt that production could be increased substantially if nest losses and hunting mortality could be better controlled. Further consideration should also be given to the possibility that the restoration program can be expanded throughout much of the transition zone and the prairie pothole region as new projects are established.

In the future the standard procedure will be to give first priority to use of preflight goslings or mated pairs from established wild breeding flocks which migrate. Second priority will be given to use of goslings from carefully selected disease-free semidomestic stock. In the North Central States preference will be given to use of *B. c. maxima* from either wild or semidomestic sources on the basis of priorities cited and availability.

Limitations on expansion of any established breeding flock are sufficient space and suitable nesting sites. Natural or artificial islands and nesting devices should be erected at least one year in advance to the period of anticipated use to allow natural recovery or weathering. The clearing of natural islands, construction of larger artificial islands with ample protection from wave action, and nesting platforms placed above spring flood elevations have proved to be the most satisfactory practices with respect to encouraging nesting. If artificial devices require annual maintenance, such as providing nesting materials in the form of hay or marsh grasses, this should be done prior to spring break-up. Care should also be used in selecting natural locations for artificial nesting devices with a view toward satisfying territorial requirements, and providing protection from predators and wind and wave action where possible. The Canada goose is a creature of habit and will return consistently to the same nesting site, once used, if it can be given some degree of permanence. The optimum distribution and density of nesting sites will ultimately depend largely upon the tolerances exhibited by the individual breeding population.

Early and continuing consideration should be given to local predation problems and influences of hunting to determine the intensity of controls to be applied, especially in the case of new projects.

Frequent reference has been made to recommendations for establishing breeding populations of Canada geese presented in the Bureau publication Wildlife Management Leaflet No. 15, and recent departures from these recommendations. Until such time as the leaflet is revised, all of the information presented still appears sound except (1) the use of immature birds-of-the-year trapped during migration, in this case *B. c. interior,* has not proved successful to date, (2) semidomestic stock may be used, if carefully screened as cited, (3) the use of covered pens for holding full-winged birds in the winter prior to release proved to be more successful than the use of brails, which require careful attention to produce satisfactory results.

Cost records for Phase I are not complete, but data have been kept for the transplant program under Phases II and III, and related habitat improvement work. Sufficient information was not readily available to permit including a realistic cost analysis in this paper.

More intensive research into physiological and psychological factors influencing breeding behavior, genetic influences, dietary and disease problems, nesting site selection, and micro-environmental factors is needed with the more successful breeding populations to obtain a better understanding of factors limiting further expansion and to improve management techniques. Negative results should also be analyzed further to determine underlying causes for unsuccessful transplanting attempts. Special efforts should be made to band a sample of goslings produced annually by all local flocks to aid in analyzing distribution and hunting mortality.

As the States expand their programs for establishment of local breeding goose flocks, a better method for coordination of state and federal programs of this nature should be developed so as to improve communication and benefit from each other's experience. It is hoped that this paper will aid in this respect.

SUMMARY

Captive flocks of Canada geese have been maintained on many national wildlife refuges and state waterfowl management areas throughout the northern tier of States since the areas were first established. Various sized groups have been introduced to serve as decoy flocks to attract migrant geese, to increase use of traditional wintering areas, and to re-establish breeding populations of Canada geese within portions of the original breeding range from which they have been absent since the early 1900's.

Introductions of local breeding flocks have met with varying degrees of success, depending upon source of breeding stock, breeding behavior, availability of suitable nesting sites, and losses from predation, natural mortality and hunting mortality.

In the future, first priority will be given to use of goslings or mated pairs from established local breeding flocks; second priority will be given to use of carefully selected semidomestic stock as cited.

Management techniques, research needs, and recommendations for continuation of the program are presented. Special attention is given to subspecific differences and adaptability of certain strains of breeding stock judged to be most suitable for use in establishing breeding populations in the North Central States.

The production by resident Canada goose flocks on 13 national wildlife refuges in the North Central Region during the period 1936-1962 has totaled 22,300, with annual production averaging 1,500-2,000 birds the past five years. Production on the major state projects cited reached 2,600 in 1962. Collectively, state and federal areas in the North Central States are now producing 4,000-4,500 geese annually. There is little doubt that production could be increased substantially through more intensive management on existing projects and expansion of the program as new areas are established, if the principal limiting factors can be controlled and there is adequate justification for such effort.

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Harold C. Hanson of the Illinois Natural History Survey for his suggestions for improving the program. Information on State programs and other suggestions and comments concerning the Canada goose restoration program were provided by H. J. Miller and M. L. Petoskey, Michigan Department of Conservation; K. E. Bednarik, Ohio Department of Natural Resources; F. B. Lee and R. L. Jessen, Minnesota Department of Conservation; R. A. Hunt, Wisconsin Department of Conservation; George Brakhage, Missouri Conservation Commission; R. D. Hart, South Dakota Department of Game, Fish, and Parks; and L. R. Jahn, Wildlife Management Institute.

CAUSES OF DEATHS OF WATERFOWL ON THE LOWER DETROIT RIVER—WINTER 1960

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From mid-March to early-April, 1960, severe losses of waterfowl occurred on the lower Detroit River. The mortality, estimated at 10,000 to 12,000 ducks (Foote 1960:2), included canvasbacks (*Aythya valisineria* [Wilson]), redheads (*A. americana* [Eyton]), greater scaups (*A. marila* [L.]), lesser scaups (*A. affinis* [Eyton]), common goldeneyes (*Bucephala clangula* [L.]), and black ducks (*Anas rubripes* Brewster). Duck names are according to the 1957 A. O. U. Checklist.

This was not the first extensive mortality of ducks on the lower Detroit River. Earlier losses have been reported by Miller and Whitlock (1948), Hunt and Ewing (1953), Hunt (1957), Hunt (1961), and Miller (1962). These authors attributed the deaths primarily to cold weather and ice and pollution.

The losses under discussion could not have been due to exclusion of the ducks from their food beds by sheets of ice. This was verified by examination of air temperatures recorded at the Detroit Metropolitan Airport during January, February, and March, 1960, and by our discussions with Game Division personnel working in the area. However, a considerable amount of oil and other wastes had been diverted into the Detroit River at the time of the waterfowl losses.

Specimens of dead waterfowl, most of them oiled, were recovered by personnel of Michigan's Game Division. Each specimen was labeled with the date and place of recovery, species, sex, and age. Subsequently, many of these specimens were turned over to the authors. We were asked to determine the nature of the oils on the feathers of a sample of the many dead ducks collected and to determine whether these oils were a factor in causing the deaths of the ducks.

We acknowledge the Michigan Water Resources Commission's provision of funds for necropsy and laboratory expenses. We extend our thanks to Michigan's Game Division and to our laboratory assistants, G. W. Cornwell and W. W. Blandin for their aid.

Spectroscopy was done by Mr. Frank Drogosz of the Chemical and Metallurgical Engineering Department, The University of Michigan. Assistance on interpretation of the spectrographs was given to us by Drs. John J. Eisch and Robert C. Taylor, Chemistry Department, and Mr. Edward A. Boettner, School of Public Health, The University of Michigan.

METHODS

Handling of Specimens. When they were received from the Game Division, each of the specimens was placed in a polyethylene bag and sealed therein. The entire collection was stored at a temperature near 0° F. until examination was to be made. From the many which we were given, the authors selected a sample of 20 specimens. We picked our sample to include specimens which appeared "fresh" for better necropsy results. We attempted to include all sexes and ages of the three duck species which had met with the greatest numerical losses. The three species were the canvasback and the two scaups. The 20 specimens used had been picked up in the Trenton Channel area (Fig. 1) on March 25, March 30, and April 1, 1960.

The following is set forth in order to locate more precisely the places in which the sample ducks were recovered. Sample ducks A, D, G, J, K, N, Q, S, and T were found along the Trenton Channel between Horse Island and Gibraltar Island, plus the several channels between Gibraltar Island and the mainland, north to the southernmost bridge crossing to Gibraltar Island. Sample ducks B, C, E, F, H, I, L, M, O, P, and R were recovered on the west side of Grosse Ile from an area extending southward from the Toll Bridge (Bridge Road) to about 3/8 mile south of the County Bridge (Grosse Ile Parkway), about opposite the Detroit Edison Company Trenton Plant.

Methods for Oil Study. Feathers were clipped from the breasts and bellies of each of the 20 specimens and the oils extracted with carbon tetrachloride (CCl_4). Each sample was kept separate. Also, feathers were clipped from the breasts and bellies of four non-oily ducks (all canvasbacks) and the natural oils extracted with CCl_4 (two ducks) and ether, $(C_2H_5)_2O$ (two ducks). Spectographs of these extracted oils were then obtained by use of a Baird infra-red spectrophotometer.

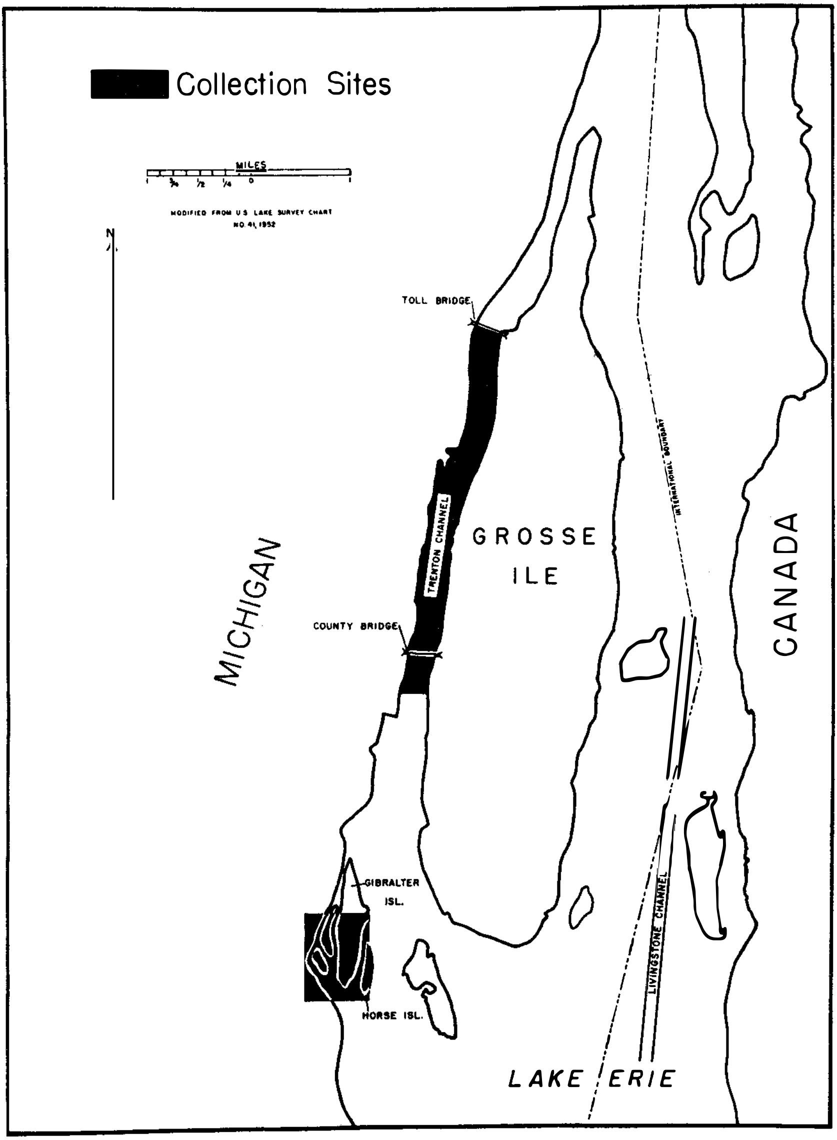

Fig. 1. Sites from which dead ducks were recovered in the lower Detroit River.

Because glyceride (non-mineral) oils were suspected, samples of Mazola oil in CCl_4 and of Mazola in $(C_2H_5)_2O$ were tested for comparisons. Control checks of the test cells and of the solvents alone were made to determine if any masking of the oils extracted from the sample ducks occurred.

Methods for Necropsies.

1. The specimen was completely thawed and weighed.
2. It was skinned and examined for any evidence of mechanical injury such as gunshot wounds, broken bones, bruises, and subcutaneous hemorrhages. Its general physical condition, as indicated by the presence or absence of subcutaneous fat and the fullness of the breast muscles, was noted and recorded.
3. The duck was placed on its back, the sternum cut free and raised, thus exposing the entire body cavity with the visceral organs intact and in place. All organs and the body cavities were examined for gross lesions and observations of abnormal conditions were made and recorded.
4. The visceral organs were removed, separated, and examined individually. Small pieces of liver and kidney were crushed on microscope slides and examined under a microscope for parasites and parasite eggs. The remainder of these organs and the lungs and pancreas were then crushed between glass plates and examined under a dissecting microscope for larger parasites.
5. The entire digestive tract was separated into its component parts, slit open, and washed out. The washings were examined for parasites under a four-power illuminated magnifier. Scrapings of the intestinal wall were taken at intervals along the entire length of the small and large intestines and from the ceca. These were examined under a microscope for parasites and parasite eggs.
6. The esophagus and proventriculus were flattened between glass plates and examined under a dissecting microscope. The lining of the gizzard was removed and scraped to detect gizzard worms. Nasal sinuses were cut open and checked under a dissecting microscope for the presence of nasal mites. The trachea, syrinx, and bronchi were opened and examined.

FINDINGS

Oil. The spectographs for the test cell check and the CCl_4 check showed that no masking of the oils tested occurred. The spectrographs resulting when $(C_2H_5)_2O$ was used indicated that ether does interfere at some wave lengths. Hence, ether was not used for the tests made on the 20 sample ducks. The spectrographs of non-oily ducks W and X (Fig. 2), the natural oils being extracted with CCl_4, show that natural oils are so low in quantity that they do not obscure or augment the results obtained from oily ducks.

The spectrograph (Fig. 3) of Mazola plus CCl_4 resulted in peaks and valleys similar to those obtained for the oily ducks (Fig. 4), particularly in the range of 2 through 7.3 microns. There were four strong bands which occurred on the 20 spectrographs of the sample ducks. They were:

3.45 to 3.55 microns
5.85 to 5.95 microns
6.9 microns
7.3 microns

These definitely indicate that esters (glycerides) were present and that hydrocarbons could have been present also. This is the first time to the authors' knowledge that esters have been shown to be

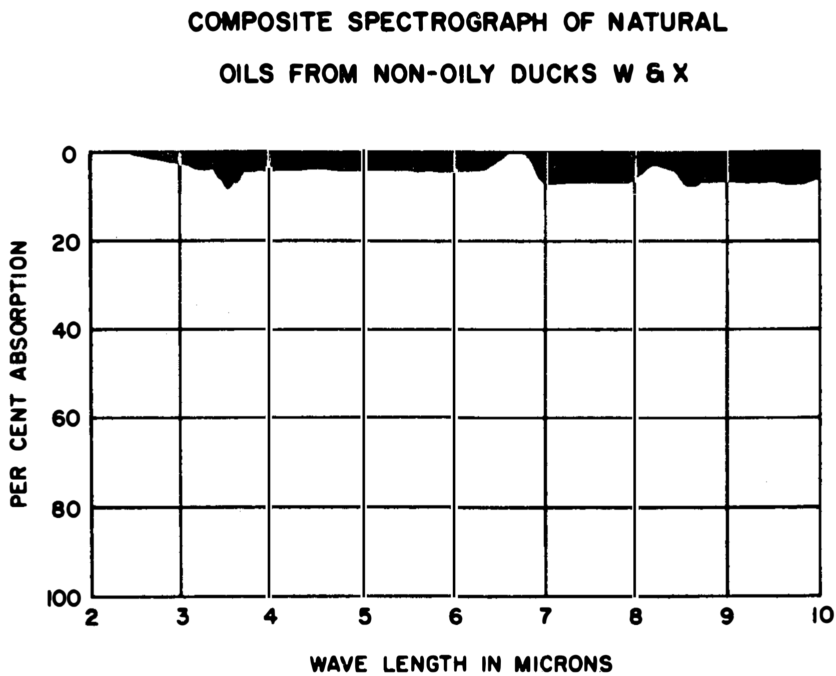

Fig. 2. Composite spectrograph of non-oily ducks W and X.

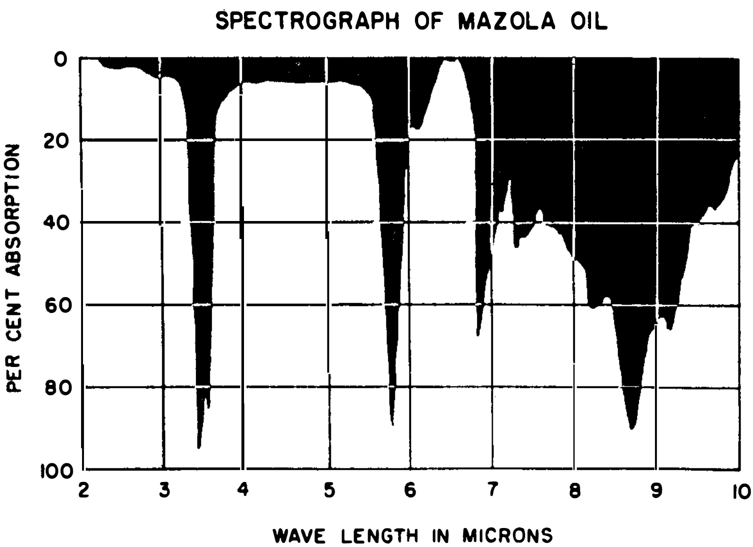

Fig. 3. Spectrograph of Mazola oil.

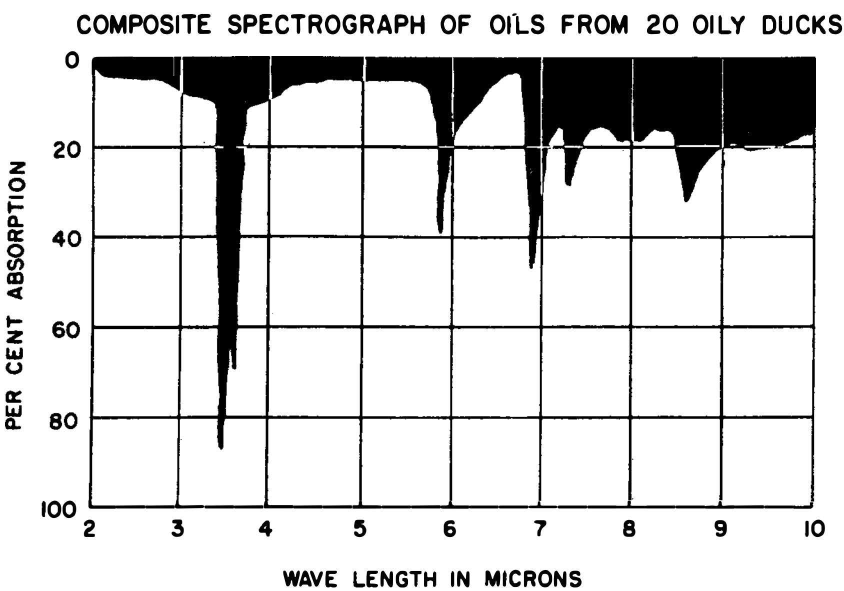

Fig. 4. Composite of spectrographs of oils extracted from feathers of the 20 oily dead ducks.

connected with the losses of waterfowl. Heretofore, only "straight" hydrocarbons have been indicated.

All the spectrographs for the oils extracted from the feathers of the 20 sample ducks (ducks A through T) showed the same general pattern of peaks and valley. This indicates that the same kinds of foreign oils were present on all 20 specimens.

A sorting of several thousand chemicals indexed on punch-cards indicated that the following compounds are the most likely to have been present:

Esters (glycerides)
$C_5H_{10}O_2$
$C_{10}H_{20}O_2$
$C_{30}H_{54}O_6$
$C_{12}H_{22}O_4$
$C_{20}H_{38}O_4$
$C_{46}H_{90}O_4$

The following hydrocarbons could have been present:
$C_{13}H_{26}O$
$C_{18}H_{34}O_2$

The authors made no attempts to determine quantities of oil on the specimens except to note its presence and to state in general the quantity. It is known that as little as one-half gram of foreign oil is enough to cause the death of lesser scaups and as little as one gram is enough to cause the death of canvasbacks (Hunt 1961:15).

Necropsies

CANVASBACKS: ALL ADULT MALES.

Necropsy A: 784.2 grams; collected 3/25/60 at Gibraltar; emaciated, moderate oily deposit on feathers. No gross lesions observed. No food in digestive tract. Very light parasite load (Table 1).

Necropsy C: 872.5 grams; collected 4/1/60 at Grosse Ile; emaciated, light oily deposit. Evidence of visceral gout. No food in digestive tract. Very light parasite burden.

Necropsy D: 849.8 grams; collected 3/25/60, at Gibraltar; very emaciated, with moderate oily deposit. Mesenteric vessels hyperemic; lower half of small intestine filled with clotted blood. Lower part of small intestine very thin walled. Villi covered with oil-like droplets. No food in digestive tract. Very light parasite load.

Necropsy G: 757.5 grams; collected 3/25/60 at Gibraltar; extremely emaciated, with moderate oily deposit. White, fleshy, subcutaneous bodies. No food in digestive tract. Light to moderate parasite burden.

TABLE 1. PARASITE BURDENS OF SPECIMENS STUDIED

Canvasback	Cestodes	Nematodes	Trematodes	Others
A	0	2	223	0
C	67	5	109	0
D	8	0	184 + In large intestine and ceca. Many eggs of 2 species of schistosomes in liver, small intestine, ceca, large intestine.	0
G	55	122	586 + Eggs of 1 species of schistosome.	0
J	17	4	396	0
K	5	2	9 + Heavy concentration of schistosome eggs in small intestine, ceca, and large intestine. 4 adults in liver.	0
N	4	30	270 + Eggs of 1 schistosome species in large intestine and cloaca.	0
Q	5	0	28 + Eggs of 1 schistosome species in liver, large intestine, and ceca.	*Aspergillus fumigatus*
R	34	7	179 + Eggs of 1 schistosome species in large intestine, ceca, and cloaca.	0
S	6	9	239 + Eggs of 1 schistosome species in small intestine and large intestine.	0
Greater Scaup				
E	90	9	941	Coccidia (?) in kidney, pancreas, and ceca.
H	79	3	1037	0
I	4	104	8508	0
M	281	14	7223	0
O	10	0	834	0
Lesser Scaup				
B	21	4	2310 + Eggs of 1 schistosome species in large intestine.	0
F	91	17	2805 + Heavy concentration of eggs of 2 species of schistosomes in small intestine, large intestine, and ceca.	0
L	6	15	1 + Eggs of 1 schistosome species in kidney, liver, small intestine, and large intestine.	0
P	24	14	299	0
T	71	5	88 + Eggs of 1 schistosome species in liver, large intestine, and ceca.	0

Necropsy J: 855.7 grams; collected 3/30/60 at Gibraltar; very emaciated, with heavy oily deposit. Evidence of visceral gout; hyperemic lungs. No food in digestive tract. Light parasite burden.
Necropsy K: 814.1 grams; collected 3/25/60 at Gibraltar; severely emaciated with light oily deposit. No gross lesions; concentrations of oil-like droplets on villi of small intestine. No food in digestive tract. Very light parasite load.
Necropsy N: 801.2 grams; collected 3/25/60 at Gibraltar; severely emaciated, with moderate oily deposit. Evidence of visceral gout. No food in digestive tract. Light parasite load.
Necropsy Q: 883 grams; collected 3/25/60 at Gibraltar; severely emaciated, with slight oily deposit. Healed shot wound in skin of neck. Extensive aspergillosis infection; esophagus and trachea

nearly occluded by host reaction to infection. Distal ends of ceca much enlarged. No food in digestive tract. Very light parasite load.
Necropsy R: 839.8 grams; collected 4/1/60 at Grosse Ile; severely emaciated, slight oily deposit. Evidence of visceral gout. No food in digestive tract. Very light parasite burden.
Necropsy S: 942.2 grams; collected 3/25/60 at Gibraltar; slightly emaciated, slight oily deposit. No gross lesions. No food in digestive tract. Very light parasite burden.

GREATER SCAUPS:

Necropsy E: Adult male, 689.4 grams; collected 4/1/60 at Grosse Ile; slightly emaciated, moderate oily deposit. Both lungs hyperemic. Had fed recently, food in digestive tract. Light to moderate parasite load.
Necropsy H: Adult female, 564.1 grams; collected 4/1/60 at Grosse Ile; slightly emaciated; light oily deposit. Lesions on surface of liver, probably post-mortem change. No food in digestive tract. Light to moderate parasite burden.
Necropsy I: Adult male, 743.5 grams; collected 4/1/60 at Grosse Ile; slightly emaciated; light oily deposit. Both lungs hyperemic; gizzard lining eroded by gizzard worm infection. No food in digestive tract. Heavy parasite burden.
Necropsy O: Adult male, 658.4 grams; collected 4/1/60 at Grosse Ile; slightly emaciated; slight oily deposit. Both lungs hyperemic. No food in digestive tract. Heavy parasite burden.
Necropsy O: Adult male, 783.0 grams; collected 4/1/60 at Grosse Ile; in good flesh; slight oily deposit. Lead shot in subcutaneous tissue of leg. Both lungs hyperemic; evidence of visceral gout; right cecum hard and distended. Digestive tract filled with food material and in good condition. Light to moderate parasite load.

LESSER SCAUPS:

Necropsy B: Adult male, 692.5 grams; collected 4/1/60 at Grosse Ile; slightly emaciated; light oily deposit. Ante-mortem neck fracture (Coup de grace administered by collector?); both lungs hyperemic; partially plugged vent. No food in digestive tract. Moderate parasite burden.
Necropsy F: Adult male, 469.1 grams; collected 4/1/60 at Grosse Ile; moderately emaciated; slight oily deposit. Right lung hyperemic. No food in digestive tract. Moderate parasite burden.
Necropsy L: Adult male, 524.7 grams; collected 4/1/60 at Grosse Ile; moderately emaciated; slight oily deposit. Both lungs hypere-

mic; opaque, amber colored droplets in crushed liver. No food in digestive tract. Very light parasite load.

Necropsy P: Adult female, 613.3 grams; collected 4/1/60 at Grosse Ile; slightly emaciated; moderate oily deposit. Evidence of visceral gout; small intestine occluded by compaction of snail shells about half way down its length; oil-like droplets on villi of small intestine. No food in digestive tract. Great deal of post-mortem change. Light parasite load.

Necropsy T: Immature male, 565.9 grams; collected 4/1/60 at Gibraltar; slightly emaciated; light oily deposit. Liver greatly hypertrophied and ruptured; many amber colored droplets prominent in crushed liver; gall bladder atrophied. No food in digestive tract. Light parasite load.

DISCUSSION

The deaths of only four of the specimens could have been due to clearly defined necropsy findings. Canvasback ''Q'' could very well have died of the aspergillus infection, though captive birds have been found to live until much more severe involvement developed.

Lesser scaup ''B'' must have died of a broken neck, perhaps coup de grace by collector. Lesser scaup "P" probably would have died, if it actually did not succumb, from the occluded intestine. And lesser scaup ''T'' may have died as a result of malfunction of the liver. It was not possible to determine whether rupture of the liver had occurred before or after death. If it was an ante-mortem event, it was most likely the cause of death.

The emaciated condition of most of the ducks examined indicated that they might have been suffering from food shortage. The fact that, with two exceptions, little or no food was found in the digestive tracts of the birds studied would bear this out. However, the canvasbacks were the only species to exhibit what was considered to be severe or extreme emaciation. This might be expected because, according to Hunt (1957:174-175), canvasbacks are generally the first species to exhibit weight loss, possibly due to their more specialized food habits.

In order to compare the condition of the ducks comprising the sample with ducks of the same species studied under other circumstances, reference was made to Hunt (1957: 180) for weights of ducks live-trapped during the early spring months. Further reference was made to Town (1960:11) for weights and parasite burdens of non-oily ducks which died on the Detroit River during the winter of 1958-59. Additional reference was made to a small sample of ducks which were live-trapped and sacrificed in March, 1960, by

Cornwell (unpublished current research), to determine their parasite burdens. These comparisons are shown in Tables 2 and 3. The parasite burdens of a "healthy" sample are from Cornwell, and the weights of the "healthy" ducks are from Hunt.

It will be noted that the parasite burdens of the ducks in question were intermediate between the findings of Cornwell and of Town. None of the infections in the present study was considered to be a major contributing factor in the death of the ducks. In the case of Town's birds the very heavy infections could have contributed materially by further weakening ducks which were already weak from malnutrition.

However, it will be noted that there is no real difference between the average weights of the ducks in Town's sample and those in ours. Furthermore, both samples are well below the average weights obtained by Hunt. If we discount the potential effects of parasitism, it would appear that food stress could have caused the deaths of the ducks in both Town's and the present study. The major feeding areas had been ice-covered prior to both series of mortalities. But the similarities between the two samples end there, and the circumstances surrounding the two collections must be examined.

Town had to work hard all winter to collect his birds. During the winter of 1959-1960, Game Division personnel were collecting specimens for our research and class use, and had found relatively few.

TABLE 2. INTENSITIES OF PARASITE INFECTIONS

	Cornwell's Healthy Sample	Town's Sample	Subject Specimens
		Cestodes	
Canvasback	0-14 (6 birds)	0-375	0-67
Greater Scaup	121 (1 bird)	0-1,950	4-281
Lesser Scaup	287 (1 bird)	0-38,000	6-91
		Nematodes	
Canvasback	2-22 (6 birds)	0-156	0-122
Greater Scaup	17 (1 bird)	0-51+	0-104
Lesser Scaup	44 (1 bird)	0-141+	4-17
		Trematodes	
Canvasback	2-365 (6 birds)	0-6,933	5-586
Greater Scaup	87 (1 bird)	5-9,105	834-8,508
Lesser Scaup	5 (1 bird)	14-30,031	1-2,805

TABLE 3. WEIGHTS OF DUCKS IN GRAMS

	Hunt's (1957) Healthy Ducks	Town's 1958-1959 Non-oily Natural Mortalities	1960 Subject Specimens
Canvasback	Ave. 1222 1134-1559	Ave. 851 523-1077	Ave. 840 757-942
Greater Scaup	Ave. 891	Approx. ave. 690 502-916	Ave. 688 564-783
Lesser Scaup	Ave. 754 561-1219	Approx. ave. 533 370-934	Ave. 573 469-692

Note: 453.6 grams = 1 pound avoirdupois.

Then in late March, 1960, when the weather was becoming milder and the food beds were opening up, and when no further natural mortality was expected, they picked up more freshly dead birds than we could handle. This was like an epizootic, but there was no evidence that a contagious disease was involved. The only common signs exhibited by the dead birds was the variable degree of weight loss and the presence of oil on their feathers.

Mass starvation of ducks, which are capable of moving long distances for food, seldom occurs with epizootic suddenness, if at all, unless there are extenuating circumstances. In this instance the oiling of a large number of birds appeared to be that extenuating circumstance.

How can oil cause ducks to lose weight and to starve? Hunt (1957:146-147) found that:

1. Oil causes matting of the feathers so that ducks will become waterlogged, lose their ability to fly, and will actually drown if they cannot get out of the water soon enough. Diving ducks feed almost exclusively in aquatic areas, and, if they cannot go onto the water, will starve unless food is provided very close at hand.
2. Oil reduces the insulating power of the feathers. The ducks lose body heat rapidly and the stored reserves of energy—carbohydrates, fats, and finally proteins—are consumed.
3. Oiled birds fail to eat normally, even when food is readily available.
4. Oiled ducks usually make an effort to preen the oil off their feathers. In so doing, they hardly can fail to ingest some oil. There are toxic substances in some oils which can cause death. It is suspected that the visceral gout found in birds of our sample may have been due, at least in part, to ingested oils; the kidneys, being damaged by toxic elements, were unable to excrete uric acid rapidly enough.

CONCLUSIONS

It is recognized that the number of ducks studied on this project is not a statistically significant sample of the total number, estimated at 12,000, which died. However, the findings are supported by a background of previous research.

It is our conclusion that a large majority, if not all, of the ducks we studied died as a result of having their feathers oiled while they were using the Detroit River in the vicinity of Gibraltar and Grosse Ile, Michigan, such oil being carried on the surface of the river.

SUMMARY

Specimens of dead waterfowl, most of them oiled, were recovered from the lower Detroit River from mid-March to early-April, 1960. A considerable amount of oil and other wastes had been diverted into the Detroit River at the time of the estimated loss of 12,000 waterfowl.

The authors were to determine the nature of the oils on the feathers of a sample of the dead ducks and to determine whether the oils were a factor in causing the deaths. To do this we randomly selected a 20-specimen sample composed of three species which had met with greatest losses—canvasback, lesser scaup, and greater scaup.

Feathers were clipped from the breasts and bellies of each of the specimens and the oils extracted with carbon tetrachloride (CCl_4). A Baird infra-red spectrophotometer was employed to determine the spectrographs of the oils.

Necropsy procedures included skinning each specimen to determine if trauma had caused death. All specimens were examined internally for parasites and lesions.

The spectrographs of the oils from the 20 specimens showed four strong bands of absorption. These were between 2 and 7.3 microns. One of the bands definitely showed that esters (glycerides) were present. This is the first time, to the authors' knowledge, that esters have been associated with the losses of waterfowl.

Most of the ducks necropsied were considerably underweight and only two had food in the digestive tract. The parasite burdens of the sample ducks were "very light" to "light" for the most part. The deaths of only four of the specimens could have been due to clearly defined trauma or biotic pathogens.

It is our conclusion that a large majority, if not all, of the ducks studied died as a result of having their feathers oiled while they were using the Detroit River in the vicinity of Gibraltar and Grosse Ile, Michigan, such oil being carried on the surface of the river.

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DISCUSSION

MR. HERB OWENS [Iowa]: I would like to ask about the oil mortality. Is oil in itself toxic? We have had quite a lot of mortality along the Mississippi River, and I would like to know just what effect it has on the ducks that causes them to die.

DR. HUNT: One factor is that the oil mats the feathers and buoyancy is reduced so the birds may actually sink and drown. We have witnessed that. When birds become oil soaked, the cold water and cold air can reach the skin easily. It reduces the temperature of the bird, and it may contract pneumonia or simply die of exposure. I would like to point out that some oils, even some natural oils, are toxic and will kill a bird if ingested.

MR. JOHN CRONIN: We have had a similar problem and for years we assumed that the cause of death was exposure to cold water, weather and so forth. Just a few years ago, after a very large kill, we noticed that many of the birds had extremely slight amounts of oil. Upon testing it we found several hundred that had what we considered to be small quantities of oil in the digestive tract and we assumed that there was some toxic substance involved. I was wondering if you would comment on how this oil might be toxic digestive-wise.

DR. HUNT: The toxic substances that are in the oil affect liver activity, and they affect kidney activity. The oil itself may very well coat the intestine, which would decrease assimilation of food or something along this line.

ROLE OF HUNTING REGULATIONS IN MIGRATORY BIRD MANAGEMENT

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The gradual accumulation of evidence that hunting regulations do not have an important effect on fall population levels of most resident small game species is probably the greatest accomplishment thus far in the history of wildlife research. This concept removed the incentive to change hunting regulations annually in response to changes in population levels and simplified the task of game managers. It has also stimulated skepticism concerning the justification for migratory game bird regulations. With migratory game birds, an attempt has been made to control through regulations the size of the kill in relation to the status of populations. When populations were low, regulations were made more restrictive in an attempt to reduce the kill. When populations were high, more liberal regulations were enacted.

Recently the view has been expressed that such changes in regulations are unnecessary. This idea apparently has stemmed from information secured through studies of resident game species. The purpose of this paper is to discuss how well the phenomena that prevent hunting mortality from affecting population levels of resident species apply to migratory game birds.

HUNTING PRESSURE (AND THEREFORE THE KILL) IS SELF LIMITING REGARDLESS OF SEASON LENGTH

Self regulation of hunting pressure is a phenomenon that prevents hunting pressure from unduly reducing population levels of resident game. Before population levels have been reduced to the point that inadequate breeding stock is left, hunting is no longer sufficiently productive to stimulate continued hunting pressure. In other words, hunting becomes so poor that hunters stop hunting long before population levels are reduced to a critical point. Many hunters tend to lose their enthusiasm for hunting soon after the season opens and hunting pressure naturally tapers off. This concept is well illustrated by the pheasant hunters who show a tremendous early effort but lose interest long before an excessive kill has occurred. The basic cause for this appears to be a reduction in hunter success as the season progresses. Apparently as populations of resident species are reduced by hunting, the remaining individuals become more widely distributed and are contacted by hunters less frequently. Migratory game birds do not benefit in this manner because they usually are gregarious and utilize a specific, limited type of habitat. Despite relatively low population levels, hunters are able to locate and harvest waterfowl effectively. Information on the hunting kill for the canvasback (Geis, 1959) clearly shows that despite a substantial kill in October and November, canvasbacks were still being harvested at a high rate in December. The pattern of hunting activity for waterfowl is not the same as that for resident species.

In the southern states, shooting pressure holds up throughout the entire season. Both the Bureau's Mail Questionnaire Survey of waterfowl hunters and the Duck Wing Collection Survey show that for states such as Florida and California, hunting activity persists throughout the season. Even in northern states, a substantial kill can occur late in the season if conditions are right. For example, the waterfowl kill in Ohio is normally heavily concentrated early in the season, yet in 1960 when a split season was placed in effect, a very substantial kill occurred in late December. Another example occurred in New York in 1958 when a heavy kill of canvasbacks occurred late in the season. Waterfowl hunters are apparently very opportunistic, and when the birds can be taken late in the season, they do not hesitate to do so. Such behavior is contrary to the indifference or lack of effort shown late in the season by hunters of resident species.

Another important difference between resident and migratory game birds is that resident species are subjected to a single hunting season and only one "opening day," while migratory game birds may have a true season length many times longer than that in any single state and which involves several "opening days" with new groups of hunters. For example, normally the shooting pressure on the mallard starts in Canada in September (or earlier in crop depradation areas) and continues in the southern states until mid-January. This is a true season length of at least four months.

The fact that hunting regulations influence the proportion of waterfowl population harvested has been clearly shown by band recovery rates. In studies conducted on the mallard (Hickey, 1952), canvasback (Geis, 1959), and black duck (Smith and Geis, 1962), there has been a strong relationship between regulations and band recovery rates. This leads to the inescapable conclusion that regulations do have an effect on the proportion of the population harvested, which leads logically to the question, "Does increased hunting skill have any effect on overall survival?"

NON-HUNTING MORTALITY FACTORS ARE DENSITY DEPENDENT; THEREFORE, THEY DECREASE AS SHOOTING MORTALITY INCREASES

The second consideration that prevents shooting pressure from influencing resident species is that if hunting mortality is increased, non-hunting mortality is reduced. As a result, the annual rate of mortality is unchanged by shooting pressure. In contrast, studies of migratory game birds have indicated that shooting pressure influences annual mortality rates. Hickey (1952) noticed the relationship between band recovery rates and mortality rates in the mallard, based on data going back to the 1920's. Lauckhart (1956) showed that one mallard population in the State of Washington with a 13.1 per cent direct recovery rate had an annual mortality rate of 57.0 per cent, while another population with a 25.6 per cent recovery rate had a 78.1 per cent annual rate of mortality. More recently an analysis of black duck banding data, now in progress at the Migra-

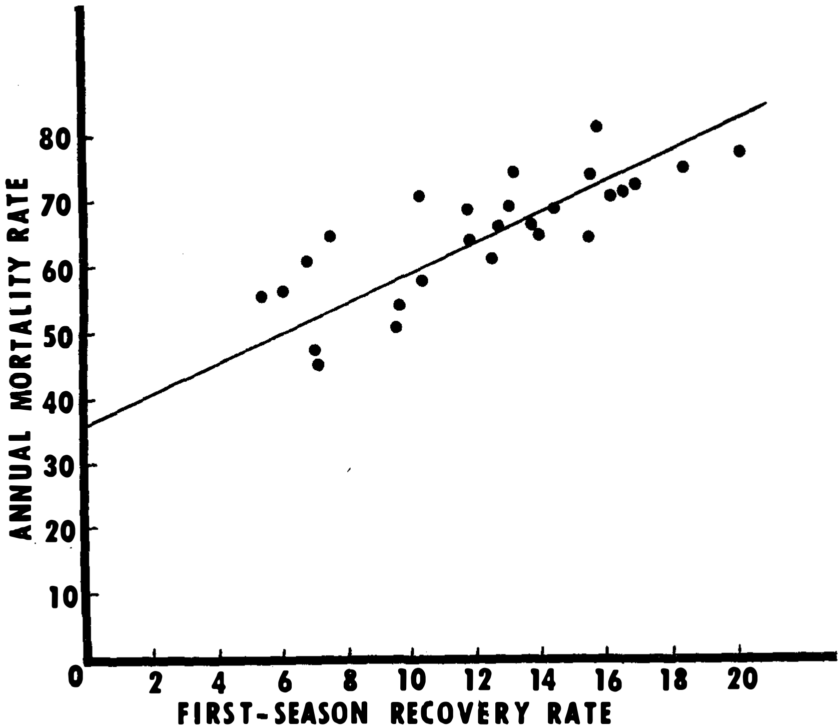

Fig. 1. Relationship between rate of hunting kill and annual mortality rate for black ducks banded as immatures (from Smith and Geis, 1962).

tory Bird Populations Station, has shown a strong correlation between shooting pressure and annual mortality rates (Figure 1). This also illustrates that shooting pressure is not responsible for all mortality and that non-hunting mortality makes up a greater fraction of the total deaths under conditions of low-shooting pressure. Thus, Figure 1 suggests that non-hunting mortality occurs in addition to and not in place of hunting mortality.

Apparently about the same fraction of the birds going into a year will be killed due to such things as accidents, oil pollution, lead poisoning, and botulism, regardless of shooting pressure. Figure 1 also implies that for black ducks during their first year, this proportion is about 37 per cent and that all mortality above that level is due to hunting. Again, the gregarious nature of migratory game birds may be responsible for non-hunting mortality being independent of population size.

Striking evidence that non-hunting mortality does not replace hunting mortality was noted for the white-winged dove. The banding of nestling white-winged doves by the Texas Game and Fish Commission made it possible to determine whether or not the closed seasons from 1954 through 1956 increased the survival rate for this bird. This was done by comparing recovery rates of samples of birds surviving similar periods of time during periods having open and closed seasons. These data are shown in Table 1. For example, the birds banded in 1954 and recovered in 1957, which had lived through three closed seasons before entering an open season, had a recovery rate of 0.9 per cent. In contrast, white wings banded in 1957 and 1958, which had lived through three years in which hunting was allowed

TABLE 1. COMPARISON OF RECOVERY RATES OF TEXAS WHITE-WINGED DOVES FOLLOWING CLOSED VERSUS OPEN HUNTING SEASONS IN TEXAS

Comparison	Status of seasons	Year of banding	Number banded	Number recovered	Recovery rate	Average (unweighted) recovery rate
Fourth hunting	Closed	1954	642	6	0.0093	0.0093
season recovery	Open	1957	1,877	3	0.0016	
rates		1958	3,601	6	0.0017	0.0017
Third hunting	Closed	1955	383	5	0.0130	0.0130
season recovery	Open	1957	1,877	10	0.0053	
rates		1958	3,601	7	0.0019	
		1959	2,809	7	0.0025	0.0032
Second hunting	Closed	1956	180	5	0.0278	0.0278
season recovery	Open	1957	1,877	13	0.0069	
rates		1958	3,601	48	0.0133	
		1959	2,809	18	0.0064	
		1960	3,041	10	0.0033	0.0075
Recovery rates	2 closed,					
during 1958	1 open	1955	383	3	0.0078	
season	1 closed,					
	1 open	1956	180	4	0.0222	0.0124
	1 open	1957	1,877	13	0.0069	0.0069

in Texas, had a less than 0.2 per cent fourth-year recovery rate. Similar comparisons were made for birds taken three and two years following banding, and the same relationship was evident. The birds, a portion of whose life included closed seasons, had a higher recovery rate than those subject to annual hunting. Since the recovery rate reflecting the number of birds surviving the period of closed seasons always related to the 1957 hunting season, a different type of comparison was made to examine the possibility that the higher recovery rate following the closed seasons was due to a heavy kill in 1957. This was done by using recovery rates for the 1958 hunting season, since survivors of both the closed seasons and open seasons would be adults at time of recovery during this season and hence comparable. The recovery rates of white-winged doves banded in 1955 and 1956 averaged 1.2 per cent, while those banded in 1957 had a 0.7 per cent recovery rate. Although the birds banded in 1955 and 1956 were four and three years old, respectively, they had a higher recovery rate than birds banded in 1957. Despite the small sample sizes upon which these comparisons are based, it can be safely concluded that closure of the hunting season increased the survival rate of white-winged doves produced in Texas. Available information indicates that shooting pressure appears to affect mortality rates of migratory game birds, which leads to the next consideration.

INVERSITY

The third phenomenon causing regulations to have little influence on the status of resident species is the discovery that increased mortality is compensated for by increased productivity. As a result, the size of the breeding population does not affect fall population levels due to an inverse relationship between size of breeding population and rate of production. This relationship has been found in resident species by a number of investigators (Errington, 1945; Bump *et al.,* 1947; and Baskett, 1947.) In order to consider how well this inverse relationship applies to migratory game birds, it is necessary to consider the factors responsible for production. In regard to ducks produced in the Prairie Provinces of Canada and the North-Central States, which provide most of the continent's duck hunting opportunity, it is obvious that the dominant factor affecting production is the status of breeding habitat resulting from climate conditions. It has been evident that there is a strong direct relationship between water conditions, measured by numbers of ponds and waterfowl production. Since climatic conditions can in no way be influenced by the size of the waterfowl population, this phenomenon of an inverse relationship between population levels and production cannot operate for those species nesting primarily in moisture-deficient areas. Bellrose, *et al.,* (1961) pointed out that mallard age ratios in the Mississippi Flyway were directly related to the number of ponds per mallard in southern Manitoba and southern Saskatchewan for the period 1955 through 1959. This might be regarded as evidence that population levels influence production. The number of ponds per duck, however, is a measure of the amount of habitat in relationship to the population rather than a measure of population level. It again emphasizes the importance that the amount of suitable habitat has on mallard production. This relationship also implies that under constant habitat conditions, a greater rate of production will occur with lower population levels. Bellrose, *et al.,* concluded, however, that the number of water areas and temperatures and associated weather conditions in April and May were the factors of major importance in production.

Although the dominant factors affecting production of Prairie nesting ducks appear to be clear, much needs to be learned about the factors influencing production of other species of migratory game birds. There is scattered evidence, however, that suggests that there is not an inverse relationship between breeding population densities and production. Mourning doves frequently nest successfully under conditions of high population density. Arctic nesting waterfowl frequently experience almost total failures in production, which is apparently due to adverse weather and flooding during the nesting season. Barry (1962) found that the timing of the spring thaw had a marked influence on brant production. Apparently the major factors influencing production of Arctic nesting waterfowl are not related to the density of the birds.

The black duck, which nests in an environment less subject to severe habitat changes, provides an interesting comparison with prairie nesting ducks in regard to the possibility that production may be influenced by population density. Also, breeding black ducks normally do not occur in high densities. Even for this species, however, available information does not suggest an inverse relationship between population density and production. Mendall and Spencer (1961) found that black duck age ratios in the kill in Maine varied just as widely during the period 1948 through 1957 (from 0.9 to 3.3 immatures per adult) as Bellrose, *et al.,* (1961) found that mallard age ratios varied in Illinois during the period 1937 to 1955 (from 0.8 to 3.2 immatures to adult). This suggests that the factors responsible for black duck production are just as variable as those for the mallard which nests in the unstable waterfowl habitat of the Prairie Provinces in Canada and in the North Central States. Furthermore, Stotts and Davis (1960) found that apparently normal production occurred under very high breeding population densities on islands in the Chesapeake Bay. On the other hand, Banko (1960) found a clear inverse relationship between breeding population size and production in Trumpeter swans. This supports the conclusion of Bellrose, *et al.*, (1961) that an inverse relationship exists within certain undefined limits. Research is needed for a better understanding of these limits. It is hoped that this information will be obtained by annual determinations of the age composition of the fall waterfowl population through the recently inaugurated Duck Wing and Goose Tail Collection Surveys, combined with an effective pre-season banding program to indicate the extent to which immatures are more vulnerable than adults to shooting.

CONCLUSIONS

Information available thus far suggests that the phenomena that cause hunting regulations to have little effect on the status of resident game species do not apply to migratory game birds. Hunting regulations influence the proportion of migratory game bird populations that are harvested which in turn influences annual mortality rates. Furthermore, there is little evidence to suggest that increased hunting mortality is compensated for by either a reduction in nonhunting mortality or by increased production. This emphasizes the important role of hunting regulations in migratory bird management.

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DISCUSSION

MR. JAMES KIMBALL [Utah]: Al, you say that hunting mortality is added to natural mortality and does not replace other mortalities. I can't really believe that you don't believe in compensating mortalities.

MR. GEIS: I don't mean it to be as inflexible as my graph stated it, but it is rather clear that we couldn't have this relationship illustrated in our figure if this didn't tend to occur.

MR. KIMBALL: That makes a little sense because, after all, after the white man came we have added a new mortality that takes about one-third of the total waterfowl population every year and, if this mortality were not being replaced, I'm afraid we would have run out of waterfowl in a hurry. Man's greatest effect on waterfowl has been the destruction of the habitat rather than the shooting.

You know very well I am not one that's going to argue we can't overshoot waterfowl. I'm certainly not disagreeing with your thesis there at all, but don't you really mean that the hunting can become the limiting factor that can overbalance other things? We still have a compensating mortality.

MR. GEIS: No, I am afraid if you look at the facts of the matter you'll find out differently.

Recently I had occasion to look at some blue-wing teal data. That was really amazing. Even among the adult blue-wing there has been an extremely low band recovery rate, but there was still this relation between mortality rate and recovery rate. It would appear, be it ever so humble, that hunting mortality did increase the annual rate of mortality. This is what the data seemed to indicate.

DR. LOCKHART [State of Washington]: Al mentioned one of my papers there. I wouldn't stand too strongly on that point that we could kill 78 percent of the mallards as the study indicated. I think if we did that we would soon run out of birds. However, I would make the statement that that population is still there or a similar mallard population is still there and that did not kill off the ducks.

At your station did the high mortality rate and the high total of band returns coincide with the decline in population? Are these high rates also reflected in a decrease in duck population? You could go a little further, saying that if we closed all the duck seasons the ducks would increase forever. It would seem to me that that is sort of the converse of what you're coming up with.

MR. GEIS: May I comment on a couple of the points you made? The population of mallards has a very high shooting pressure and also a high mortality rate along the Pacific Coast. This has been something that has been prevalent for some time, and it would appear entirely conceivable that the reason that this population maintains itself is that the young birds that are produced elsewhere and produced by birds that winter elsewhere continue to come in and utilize this area.

Actually, it's very difficult due to the complicating influences—variations in production and other things—to relate changes in shooting pressure vs. population level. Perhaps our best opportunity to do this might be to see what happens under the very restrictive regulations that have been in effect in the last few years.

For example, I was quite interested in what would happen to the black duck under the more restrictive regulations that we have had. Unfortunately, the birds haven't been producing. For the third year in a row their age ratio has gone down. Certainly we are going to watch this and I can't help but think if you can increase the survival rate of birds and hence increase their breeding population level that we can't help but have a favorable situation in regard to a recovery of the population.

DISCUSSION LEADER FRYE: There's one question I would like to ask and I'm surprised it hasn't come up yet. I think all of us recognize and agree that a less liberal season might result in saving some ducks. A question many of us have asked is whether or not it is necessary to save these ducks when we don't have any place for them to go after they get saved.

I am quite certain that with quail in Florida we could increase the total kill by having much longer seasons, but I am also just as sure that it would have absolutely no effect on next year's crop.

MR. GEIS: I would like to know who the Solomon is that will know in August when the waterfowl regulations are set what habitat conditions will be for the following summer in the breeding grounds. The Bureau has as its first obligation the protection of resources and they would have to take an awful pessimistic view to conclude that the poor conditions that exist will continue.

MR. CHARLES MCINNES: Hunting is undoubtedly an important factor but there is also the considerable effect of population level on the resources. This, unfortunately, has been very hard to measure. From the available information it appears that if competition for nest sites is severe in the late spring that a certain proportion of the population will fail to breed entirely. Unfortunately, if they do not breed it's hard to say how many or what fraction of the population is involved. However, it doesn't appear that the population has been affected even in the face of this adverse condition.

Secondly, I think perhaps a little more attention must be given to the effect of the phenomena of the winter range on breeding of birds the following spring. The situation was presented to us in the Arctic geese that the energy which goes into their egg, that is to say, the food which eventually turns up as egg yolk comes from somewhere other than the breeding grounds. These birds arrived in at a time when very little food was available. There was almost no feeding, yet they got right down to the business of laying eggs. So, it is apparent that the wintering ground did have a very definite effect on production.

The trouble is that we haven't been able to measure the lack of birth rate.

MR. GEIS: Of course, all we look at is mortality rate. The productive rate of the various populations plotted on that chart has very little bearing on it.

TECHNICAL SESSION

Monday Afternoon—March 4

Chairman: Lars Karstad
Head, Division of Wildlife Diseases, Ontario Veterinary College, Guelph, Ontario

Discussion Leader: Robert W. Davis
Professor and Head, Department of Anatomy, Colorado State University, Fort Collins

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DISEASE, NUTRITION, AND CONTROLS

HELMINTH POPULATIONS OF THE CANVASBACK *(AYTHYA VALISINERIA)* AND HOST-PARASITE-ENVIRONMENTAL INTERRELATIONSHIPS

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Department of Wildlife Management, the University of Michigan, Ann Arbor

The relationship of helminth populations in wild waterfowl to the many environmental factors controlling them are poorly understood and seldom studied. The common practice of conducting helminthfauna surveys of many host species sheds little light on the ecology of parasitism, or its effects on the host. This report is a host-oriented approach to the results of helminthfauna surveys of 180 canvasbacks (*Aythya valisineria*) collected from several geographically and ecologically distinct environments. Our findings are stratified by sex, age, season collected, collection site, physical condition, brood mates, and molting adults (Tables 1 and 2).

Canvasback collections were made in three areas:

(1) *The Lower Detroit River:* The late fall and winter specimens were collected here from an unstable canvasback population characterized by egress and ingress. Because this population sustains an

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annual winter mortality of varying severity, we were able to collect both moribund and apparently healthy birds for comparison of helminth populations. The area, its waterfowl populations, and winter mortality are well described by Hunt (1957 and 1961), Hunt and Cowan (in manuscript), and Cornwell, Cowan, and Hunt (1961).

(2) *The Large Marshes at the South End of Lake Manitoba:* Adults and ducklings were taken during the months of May through September on the Delta Marsh and its eastward extension, the Lake Francis Marsh. A description of this area is found in Hochbaum (1944:36).

(3) *The Minnedosa Potholes:* The third major collecting area, approximately 80 miles northwest of Delta, Manitoba is a region of small kettle-hole marshes in the midst of agricultural lands, one of the most important canvasback breeding areas in North America. It has been described by Dzubin (1955:281) and Evans (1952:2-16).

Six canvasbacks were collected in early fall at Lake Winnipegosis in north-central Manitoba. Three molting adults were collected by biologists of Ducks Unlimited in early fall from unknown lakes in northern Alberta.

Separate examination was made of the esophagus, proventriculus, ventriculus, duodenum, ileum and jejunum, ceca, large intestine, cloaca, bursa, oviduct, syrinx, nares, trachea, air sacs, lungs, liver, kidneys, pancreas, spleen, gall bladder, heart, and body fluids. Contents of the gastro-intestinal tract were washed and examined with a binocular dissecting microscope, and scrapings for microscopic study were taken from the small intestine, ceca, and large intestine. Parenchymatous organs were crushed between glass plates and examined under magnification with transmitted light. Microscopic preparations were initially made of kidney and liver tissues, but were discontinued after the first hundred necropsies. Nematodes were preserved in 70 per cent alcohol with 10 per cent glycerine. They were cleared in lacto-phenol and mounted in glycerine jelly. Cestodes, trematodes, and acanthocephalans were preserved in AFA, stained in Semichon's aceto-carmine, cleared in terpineol and mounted in piccolyte.

A technique was developed to quantify the physical condition of a bird by measuring the depth of the breast muscles and equating it to the depth of the keel. A standard point for measurement was selected as 1″ from the anterior end and 1 cm. to the right of the keel. The perpendicular distance from the edge of the keel to the sternum is then measured with a probe, calibrated in millimeters. This measurement serves as the denominator of a fraction, the Emaciation Index (E.I.) whose numerator is the depth of the muscle tissue. A drake canvasback in prime condition would thus have an E.I. of .89

$$\frac{24 \text{ mm muscle}}{27 \text{ mm keel}}$$

and one in poor condition might have an E.I. of 0.25 (7,27). The E.I. may have wide application for evaluating the physical condition of the birds.

PARASITE COMMUNITIES

Because of morphological, physiological, and biochemical differences, each organ and sometimes even different tissues of the same organ, may be regarded as a unique environment with a distinctive helminth community. An understanding of the host-parasite relationship is best served by the study of these parasite communities. Statistics of total parasite loads, obtained by grouping all the helminths found in the host, are easily derived. But, they mask the distribution of parasites in the different environments provided by the host, and could lead to an artificial evaluation of the parasite population *in situ.*

We are, therefore, reporting our data as the helminths were found in the host's organs and tissues.

Esophagus: The nematode, *Capillaria contorta,* is the only common resident, occurring in 25 per cent of the adults and 6 per cent of the ducklings. It is usually present in small numbers—96 per cent of the infections were of less than ten worms. When heavy nematode infections ocur in the proventriculus, usually in ducklings, some of the proventriculus nematodes will be found in the posterior part of the esophagus, occupying in a real sense the ecotone between the two organs. Male and immature *Tetrameres spinosa and T. crami* were found thus in 20 per cent of the adult and 70 per cent of the duckling esophagi with one-sixth of the infections entailing more than 25 worms, all in ducklings. Only rarely, and in small numbers, were other nematodes encountered.

In the case of one duckling, a single mature echinostome (Trematoda) was found embedded in the tissues of the esophagus. The occurrence of other trematodes and cestodes is believed to be the result of post-mortem migration and/or reverse peristalsis.

Proventriculus: Four-fifths of the canvasbacks had nematode infections of the proventriculus. *T. crami* and *T. spinosa* were more common in ducklings, 92 per cent, than in adults, 66 per cent. Ducklings were also more heavily infected, with 42 per cent harboring more than 25 worms compared to 11 per cent of the adults. While other nematodes were less commonly found, one-fifth of the ducklings were infected by *Echinuria* spp., extremely pathogenic helminths which cause extensive tissue damage, morbidity, and death (Cornwell, 1963).

Neither tapeworms nor flukes appeared to be resident in the proventriculus.

Ventriculus: Gizzard nematodes were found residing under the koilin lining in four-fifths of the adults and ducklings. Ducklings were most heavily infected, 48 per cent having more than 25 worms compared to only 9 per cent of the adults. The most common helminths were *Amidostomum* spp. and *Epomidiostomum* spp., although species of *Streptocara, Echinuria, Tetrameres,* and several other unidentified individuals were encountered.

Of particular interest was the presence of the cestode *Gastrotaenia cygni,* under the gizzard lining in one-fifth of the adults and one-half of the ducklings. Severity of infections ranged from 1 to 72, with a mean incidence of 16 ± 3. These tapeworms caused extensive damage to the koilin lining and the epithelium. They also were the only resident cestodes observed in the upper gastro-intestinal tract of the canvasbacks examined.

While the upper part of the gastro-intestinal tract is characteristically occupied by tissue-feeding nematodes, the lower portion is home to large numbers of cestodes and trematodes of many species, which usually derive their nutrition from the contents of the gut.

Duodenum: Slightly over one-half of the duodenums had tapeworm populations, 42 per cent of which numbered less than 100. Ducklings were infected twice as often, and with nearly twice as many tapeworms as the adults.

Fimbriaria fasciolaris was the most common cestode found in the duodenum, and it reached its greatest numbers there, although occurring in the remainder of the small intestine. The majority of cestode species were hymenolepids, but their specific identity has not been ascertained.

In practically every instance, trematode infections in the small intestine were composed of echinostome and strigeid species. Sixty-one per cent of the adults and 59 per cent of the ducklings had flukes in the duodenum, and the young were again more heavily parasitized than adults, twice as many carrying over 100 flukes. Nematodes were not commonly found in this organ, and when present were usually immature *Tetrameres* spp.

The Remaining Small Intestine: Extremely heavy infections of cestodes and trematodes may be found in this organ, depending upon the host's age, time of year, feeding habits and food preference, specific water area, time spent upon that water area, and the availability of infective stages of the parasites. Of the 180 canvasbacks examined, only seven had no helminths in the small intestine.

Parasite loads were regularly either quite small, slightly more than one-half below 250 helminths, or large, one-fourth with more than 1,000 worms. The mean infection in ducklings, 1602±441, was larger than that in adults, 221±82. Trematodes, too, were more frequent and in greater numbers in ducklings than adults, but the differences were not large.

Schistosome eggs were present in 55 per cent of the gastro-intestinal tracts. Nearly equal percentages of adults (57) and juveniles (53) carried schistosomes.

Nematodes were uncommon in the small intestine, with only 16 of 180 canvasbacks bearing infections, half of which were ducklings. *Capillaria* spp. were the most frequently encountered nematodes; but 3 birds contained one or more large ascarids, and all 8 infected ducklings had larval male *Tetrameres* spp.

Acanthocephalans were found in 16 per cent of the small intestines, and one-half of the infected ducklings and adults were collected from the Delta and Lake Francis Marshes.

Large Intestine: Small populations of echinostomes are typical of the large intestine, 66 per cent of which were infected by trematodes. Cestodes were present in one-tenth of the adults and one-fifth of the young, but usually, 89 per cent, in numbers less than 10. The mean trematode infection in adults was 23±13, and 33±8 in ducklings. When large notocotylid (trematode) infections occurred in the ceca of ducklings, some overflow into the large intestine was evident. The incidence of nematodes, 3 per cent, and acanthocephalans, 1 per cent, was low in this organ.

Ceca: Trematodes, primarily *Zygocotyle* spp. and *Notocotylus* spp., were in the ceca of 53 per cent of the adult and 82 per cent of the young canvasbacks. The mean infection in ducklings, 50±13, was greater than that in adults, 13±8, as was the frequency of infection. The other trematodes and the few cestode infections found, 12 percent, were not typical components of the cecal community.

Nematodes, usually *Capillaria* spp., were present in small numbers, in 28 per cent of the adults and 40 per cent of the ducklings. Ninety-five per cent of these infected ducks had less than 10 capillariid worms. The only other nematodes encountered were immature *Tetrameres* spp. from ducklings with heavy infections in the proventriculus.

Cloaca: Cestodes in the cloaca were most commonly *Hymenolepis megalops*, which occurred in 48 per cent of the adults and 44 per cent of the ducklings, with 93 per cent of the infections involving fewer than ten worms. Echinostomes and strigeids were found in

23 per cent of the total sample. They were present only in small numbers and were probably there because they were being temporarily retained by the cloacal folds before excretion.

Bursa of Fabricius and Oviduct: Sixteen of 85 immature canvasbacks had parasites in the bursa. All of these were present in small numbers and appeared to be of the same species as the other helminths in the lower gastro-intestinal tract. No distinctive parasite population existed within the bursa, the parasite burdens merely being the result of overflow from more populated parts of the gut.

No parasite was found in the 72 oviducts examined.

Respiratory Tract: The trematode, *Typhlocoeleum cymbium,* was found in the respiratory passages of 5 per cent of the adults and 42 per cent of the ducklings. Infections were always small, 93 per cent being less than ten worms. The few other helminths found in this organ system, with two exceptions, are tentatively thought to be the result of contamination. The exceptions were immature *Tetrameres* spp. in two ducklings with heavy proventricular infections, where more than 10 of these nematodes were found in the lungs of each specimen.

Liver, Kidney, Spleen, and Panacreas: No helminths were found in the spleen or pancreas. Trematodes were the only worms present in the liver, 2 per cent, and kidney, 13 per cent. Nearly all of the worms recovered were schistosomes of at least three species, the most common being *Dendritobilharzia* sp. One liver contained a small population of unidentified trematodes.

Heart, Blood, and Body Fluids: Aside from the intestinal contamination unavoidable in gunshot birds, the only helminths recovered were schistosomes and a few *Typhlocoelum* sp.

A part of these data are included in Table 1.

HELMINTHFAUNA POPULATIONS AS OBSERVED IN DIFFERENT SAMPLES

Total Sample: The various canvasback samples can only be combined if we assume them to be part of the same population. A continental canvasback population may exist for some aspects of the species biology, but the means and standard errors in Table 2 show large differences in parasitism between samples. Major variations even exist in the helminth numbers of ducklings in the same brood. Final identification of the helminth species infecting the necropsied canvasbacks will undoubtedly reveal an assemblage of parasite species characteristic of the host. The parasite populations of individuals, however, seem to be determined by many factors, one of the most important being the food preferences of each host. Nonetheless, the samples are grouped, with reservations and a recognition of the artificiality of such a compilation.

TABLE 1. THE DISTRIBUTION OF THE HELMINTHFAUNA WITHIN THE HOST'S TISSUES

	Total Sample						Total Adults						Total Ducklings					
Upper Gastro-Intestinal Tract	No.	%	1-10	11-30	31-50	51+	No.	%	1-10	11-30	31-50	51+	No.	%	1-10	11-30	31-50	51+
Total Infected	176	98	50	47	25	54	94	99	46	30	7	11	82	96	4	17	18	43
Esophagus	104	58	79	12	5	8	39	41	34	5	....	....	65	76	45	7	5	8
Nematodes	99	55	75	12	6	6	37	39	32	5	....	....	62	73	43	7	6	6
Trematodes	14	8	13	1	....	....	6	6	6	....	....	....	8	9	7	1	....	....
Cestodes	8	4	7	....	1	....	1	1	1	....	....	....	7	8	6	....	1	....
Proventriculus	144	80	54	58	8	24	65	68	36	25	1	3	79	93	18	33	7	21
Nematodes	142	79	56	57	6	23	64	67	37	24	1	2	78	92	19	33	5	21
Trematodes	19	11	15	2	1	1	7	7	5	1	....	1	12	14	10	1	1	....
Cestodes	7	4	5	....	....	2	1	1	1	....	....	....	6	7	4	....	....	2
Gizzard	163	91	87	53	8	15	85	89	66	15	2	2	78	92	21	38	6	13
Nematodes	147	82	111	32	2	2	77	81	64	15	1	....	70	82	47	20	1	2
Trematodes	27	15	17	6	4	....	9	9	7	2	....	....	18	21	10	4	4	....
Cestodes	68	38	35	26	1	6	20	21	14	5	....	1	48	56	21	21	1	5
Lower Gastro-Intestinal Tract	No.	%	1-50	51-250	251-1000	1001+	No.	%	1-50	51-250	251-1000	1001+	No.	%	1-50	51-250	251-1000	1001+
Total Infected	179	99	49	39	36	55	95	100	43	27	13	12	84	99	6	12	23	43
Duodenum	144	80	62	33	25	24	69	73	45	13	7	4	75	88	17	20	18	20
Nematodes	6	3	6	....	....	....	2	2	2	....	....	....	4	5	4	....	....	....
Trematodes	108	60	66	26	13	3	58	61	40	13	2	3	50	59	26	13	11	....
Cestodes	101	56	42	26	16	17	30	32	23	2	4	1	71	84	19	24	12	16
Small Intestine	173	96	64	28	40	41	90	95	52	17	13	8	83	98	12	11	27	33
Nematodes	16	9	16	....	....	....	8	8	8	....	....	....	8	9	8	....	....	....
Trematodes	135	75	79	28	21	7	66	69	43	15	6	2	69	81	36	13	15	5
Cestodes	164	91	79	20	34	31	82	86	62	9	6	5	82	96	17	11	28	26
Acanthocephalans	29	16	28	1	....	....	3	3	3	....	....	....	26	31	25	1	....	....
Large Intestine	119	66	109	9	1	....	48	51	46	2	....	....	71	84	63	7	1	....
Nematodes	6	3	6	....	....	....	1	1	1	....	....	....	5	6	5	....	....	....
Trematodes	108	60	98	9	1	....	43	45	41	2	....	....	65	76	57	7	1	....
Cestodes	28	16	28	....	....	....	9	9	9	....	....	....	19	21	19	....	....	....
Acanthocephalans	2	1	2	....	....	....	....	....	....	....	....	....	2	2	2	....	....	....
Lower Gastro-Intestinal Tract	No.	%	1-50	51-250	251-1000	1001+	No.	%	1-50	51-250	251-1000	1001+	No.	%	1-50	51-250	251-1000	1001+
Ceca	130	72	118	10	2	....	60	63	58	1	1	....	70	82	60	9	1	....
Nematodes	61	34	61	....	....	....	27	28	27	....	....	....	34	40	34	....	....	....
Trematodes	120	67	103	14	3	....	50	53	48	1	1	....	70	82	55	13	2	....
Cestodes	22	12	22	....	....	....	8	8	8	....	....	....	14	16	14	....	....	....
Cloaca	110	61	109	1	....	....	55	58	55	....	....	....	55	65	54	1	....	....
Nematodes	3	2	3	....	....	....	....	....	....	....	....	....	3	4	3	....	....	....
Trematodes	42	23	41	1	....	....	16	17	16	....	....	....	26	31	25	1	....	....
Cestodes	84	47	84	....	....	....	46	48	46	....	....	....	38	45	38	....	....	....

Upper Gastro-Intestinal Tract	Detroit River "Normal" No.	%	1-10	11-30	31-50	51+	Detroit River Diseased No.	%	1-10	11-30	31-50	51+	Breeding Grounds Adults No.	%	1-10	11-30	31-50	51+
Total Infected	42	98	28	12	1	1	16	100	6	7	2	1	36	100	12	11	4	9
Esophagus	17	40	17	....	....	....	8	50	7	1	....	....	14	39	10	4	....	....
Nematodes	16	37	16	....	....	....	8	50	7	1	....	....	13	36	9	4	....	....
Trematodes	1	2	1	....	....	....	2	13	2	....	....	....	3	8	3	....	....	....
Cestodes	....	....	....	....	....	....	....	....	....	....	....	....	1	3	1	....	....	....
Proventriculus	22	51	16	5	....	1	13	81	8	4	....	1	30	83	12	16	1	1
Nematodes	22	51	16	5	....	1	12	75	9	3	....	....	30	83	12	16	1	1
Trematodes	1	2	1	....	....	....	3	19	1	1	....	1	3	8	3	....	....	....
Cestodes	1	2	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Gizzard	38	88	32	6	....	....	16	100	14	1	1	....	31	86	20	8	1	2
Nematodes	37	86	31	6	....	....	16	100	15	....	1	....	24	67	18	6	....	....
Trematodes	1	2	1	....	....	....	1	6	....	1	....	....	7	19	6	1	....	....
Cestodes	3	7	3	....	....	....	1	6	1	....	....	....	16	45	10	5	....	1
Lower Gastro-Intestinal Tract	**No.**	**%**	**1-50**	**51-250**	**251-1000**	**1001+**	**No.**	**%**	**1-50**	**51 250**	**251-1000**	**1001+**	**No.**	**%**	**1-50**	**51-250**	**251-1000**	**1001+**
Total Infected	43	100	26	11	4	2	16	100	4	4	5	3	36	100	13	12	4	7
Duodenum	26	61	21	3	1	1	12	75	6	3	1	2	31	86	18	7	5	1
Nematodes	2	5	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Trematodes	25	58	20	3	1	1	11	69	5	3	1	2	22	61	15	7	....	....
Cestodes	3	7	3	....	....	....	2	13	2	....	....	....	25	70	18	2	4	1
Lower Gastro-Intestinal Tract	**No.**	**%**	**1-50**	**51-250**	**251-1000**	**1001+**	**No.**	**%**	**1-50**	**51-250**	**251-1000**	**1001+**	**No.**	**%**	**1-50**	**51-250**	**251-1000**	**1001+**
Small Intestine	42	98	31	6	4	1	15	100	5	4	4	2	33	92	16	7	5	5
Nematodes	3	7	3	....	....	....	3	19	3	....	....	....	2	6	2	....	....	....
Trematodes	31	72	24	5	2	....	13	81	3	6	2	2	22	61	16	4	2	....
Cestodes	35	81	30	2	2	1	15	94	14	1	....	....	32	89	18	6	4	4
Acanthocephalans	....	....	....	....	....	....	....	....	....	....	....	....	3	8	3	....	....	....
Large Intestine	25	58	25	....	....	....	6	38	6	....	....	....	17	47	15	2	....	....
Nematodes	1	2	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Trematodes	22	51	22	....	....	....	6	38	6	....	....	....	15	42	13	2	....	....
Cestodes	3	7	3	....	....	....	....	....	....	....	....	....	6	17	6	....	....	....
Acanthocephalans	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Ceca	26	61	26	....	....	....	8	50	8	....	....	....	26	72	24	1	1	....
Nematodes	10	23	10	....	....	....	1	6	1	....	....	....	16	45	16	....	....	....
Trematodes	21	49	21	....	....	....	8	50	8	....	....	....	21	58	19	1	1	....
Cestodes	3	7	3	....	....	....	1	6	1	....	....	....	4	11	4	....	....	....
Cloaca	20	47	20	....	....	....	12	75	12	....	....	....	23	64	23	....	....	....
Nematodes	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Trematodes	9	21	9	....	....	....	7	44	7	....	....	....	....	....	....	....	....	....
Cestodes	14	33	14	....	....	....	9	56	9	....	....	....	23	64	23	....	....	....

	Molting Lake Adults						Pothole Ducklings						Marsh Ducklings					
Upper Gastro-Intestinal Tract	No.	%	1-10	11-30	31-50	51+	No.	%	1-10	11-30	31-50	51+	No.	%	1-10	11-30	31-50	51+
Total Infected	6	100	1	2	....	3	62	97	....	12	15	35	20	95	4	5	3	8
Esophagus	5	83	3	2	....	....	51	80	32	6	5	8	14	67	13	1	....	....
Nematodes	3	50	2	1	....	....	48	75	30	6	6	6	14	67	13	1	....	....
Trematodes	2	33	1	1	....	....	6	9	5	1	....	....	2	10	2	....	....	....
Cestodes	....	....	....	....	....	....	7	11	6	....	1	....	....	....	....	....	....	....
Proventriculus	6	100	1	2	1	2	62	97	10	25	6	21	17	81	8	8	1	....
Nematodes	4	67	1	2	1	....	61	95	11	26	4	20	17	81	8	7	1	1
Trematodes	2	33	....	....	....	2	9	14	7	1	1	....	3	14	3	....	....	....
Cestodes	....	....	....	....	....	....	6	9	4	....	....	2	....	....	....	....	....	....
Gizzard	3	50	3	....	....	....	60	94	13	34	6	7	18	86	8	4	....	6
Nematodes	1	17	1	....	....	....	53	83	35	16	1	1	17	81	12	4	....	1
Trematodes	1	17	1	....	....	....	12	19	7	3	2	....	6	29	3	1	2	....
Cestodes	2	33	2	....	....	....	48	75	21	21	1	5	....	....	....	....	....	....

Lower Gastro-Intestinal Tract	No.	%	1-50	51-250	251-1000	1001+	No.	%	1-50	51-250	251-1000	1001+	No.	%	1-50	51-250	251-1000	1001+
Total Infected	6	100	5	1	....	....	63	98	4	8	22	29	21	100	2	4	1	14
Duodenum	4	67	4	....	....	....	55	86	13	18	15	9	20	95	4	2	3	11
Nematodes	....	....	....	....	....	....	1	2	1	....	....	....	3	14	3	....	....	....
Trematodes	1	17	1	....	....	....	37	58	17	12	8	....	14	67	9	2	3	....
Cestodes	4	67	4	....	....	....	51	80	14	21	8	8	20	95	5	3	4	8
Small Intestine	5	83	5	....	....	....	62	97	8	8	25	21	21	100	4	3	2	12
Nematodes	....	....	....	....	....	....	5	8	5	....	....	....	3	14	3	....	....	....
Trematodes	2	33	2	....	....	....	53	83	26	12	12	3	16	76	10	1	3	2
Cestodes	5	83	5	....	....	....	61	95	12	9	25	15	21	100	5	2	3	11
Acanthocephalans	1	17	1	....	....	....	15	23	14	1	....	....	11	52	11	....	....	....
Large Intestine	2	33	2	....	....	....	55	86	49	5	1	....	16	76	14	2	....	....
Nematodes	....	....	....	....	....	....	3	5	3	....	....	....	2	10	2	....	....	....
Trematodes	1	17	1	....	....	....	52	81	46	5	1	....	13	62	11	2	....	....
Cestodes	....	....	....	....	....	....	15	23	15	....	....	....	4	19	4	....	....	....
Acanthocephalans	2	33	2	....	....	....	....	....	....	....	....	....	2	10	2	....	....	....
Ceca	4	67	4	....	....	....	58	91	48	9	1	....	12	57	12	....	....	....
Nematodes	4	67	4	....	....	....	28	44	28	....	....	....	6	29	6	....	....	....
Trematodes	1	17	1	....	....	....	53	83	44	8	1	....	17	81	11	5	1	....
Cestodes	....	....	....	....	....	....	14	22	14	....	....	....	....	....	....	....	....	....
Cloaca	4	67	4	....	....	....	39	61	38	1	....	....	16	76	16	....	....	....
Nematodes	....	....	....	....	....	....	2	3	2	....	....	....	1	5	1	....	....	....
Trematodes	1	17	1	....	....	....	21	33	20	1	....	....	5	24	5	....	....	....
Cestodes	4	67	4	....	....	....	26	41	26	....	....	....	12	57	12	....	....	....

In only one of the 180 canvasbacks necropsied did we find an absence of helminths, a duckling one to two days old. The presence of helminths is a part of the normal host biology, as shown by a 99.4 per cent rate of infection. Helminth infections are usually small, as more than one-third of the birds carried less than 100 helminths and a total of 105 had helminth populations numbering less than 500. Yet, a group of 59 ducks, including 47 ducklings, were parasitized by more than 1,000 worms. An eight-week-old duckling was the most heavily parasitized, bearing a total worm budren of 40,464.

The small intestine was the most often infected organ in the lower gastro-intestinal tract at a rate of 96 percent. Tapeworms were encountered in the intestinal lumen in 91 per cent of the infected individuals. Ninety per cent of the gizzards were infected, and it was the

HELMINTH POPULATIONS OF DUCKLINGS AND ADULTS

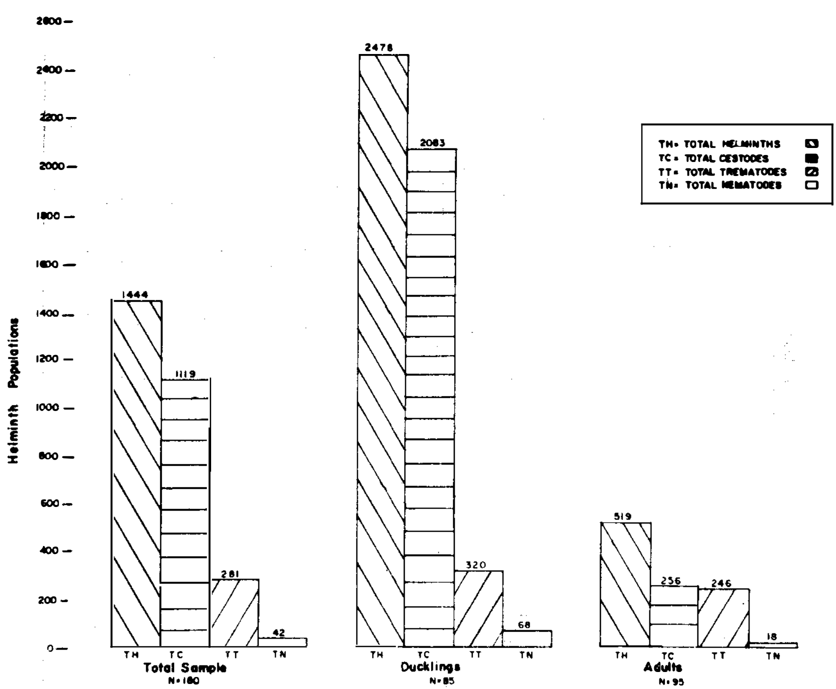

Figure 1. Helminth Populations •f Ducklings and Adults.

most parasitized part of the upper tract. Nematodes were present in 81 per cent of the gizzard infections.

Total Adults versus Total Ducklings: Duckling worm burdens were startlingly greater than those of adults, as seen in Figure 1. Forty-six of the 94 infected adults had ten or fewer worms in the upper gastro-intestinal tract, and only 11 carried more than 50 helminths. But of the 82 infected upper tracts of ducklings, one-half were parasitized by more than 50 worms, and half of these exceeded 100 parasites.

Infections in the lower tract are even more revealing. While both groups were essentially 100 per cent parasitized, more than one-half of the ducklings (43) carried over 1000 helminths, and only six had 50 worms or less. Nearly half of the adults (43), however, had less than 50 worms, and only 16 harbored more than 1000 helminths.

Detroit River "Normal" versus Detroit River Diseased: Thirty-two "normal" canvasbacks were collected in 1960 and 11 in 1961-62 on the Detroit River. They were classified as "normal" on the basis of weight, fat accumulations, ability to fly, and the fact that they were actively feeding when live-trapped. The 16 diseased birds, in contrast, were either dead when collected or in a moribund condition. They were extremely emaciated, with a mean E. I. of .45 compared to .65 for the "normal" birds. Seldom was there a trace of food in the digestive tracts of the diseased specimens. These three groups are collated in Figure 2. Aside from the 100 per cent infection, the mean total helminth load in the diseased group is more than four times the burden in those considered "normal." These diseased canvasbacks carried seven times as many trematodes as the "normals." The 1961-62 "normal" worm load would more closely fit that of 1960 except for the inclusion of a marginal individual with 1,830 cestodes in the small intestine. This large cestode burden was unusual because Detroit River canvasbacks typically have surprisingly few cestodes. Only four of the 59 examined had tapeworm infections exceeding 200.

Eight "normal" birds taken in 1962 reflect the exceptional variations found in these helminth populations. Five canvasbacks, taken together on January 22, carried a mean total of 13 helminths. The other three, collected two days later at the same site, had a mean of 310 helminths. Even with the best of intentions, the combining of such groups may hinder as much as it helps.

Canadian Adults: Of the 36 adult canvasbacks shot in Manitoba, 23 were collected on potholes, 7 on marshes, and 6 on large molting lakes. The mean helminth populations of these assemblages are

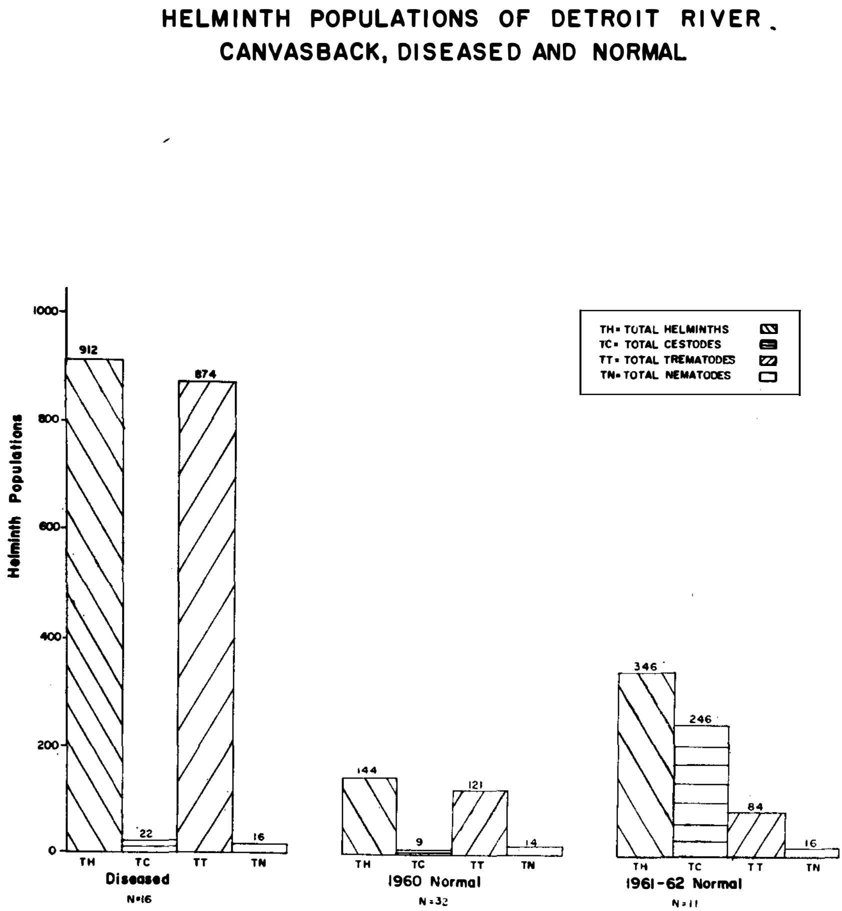

Figure 2. Helminth Populations of Detroit River Canvasback, Diseased, and Normal.

collated in Figure 3. The greater infections of adults from marshes are more apparent than real because one of the sample had 7,186 cestodes and greatly distorted the mean. As in the other groupings, the variances and standard errors are very large, making reliable summation difficult. It is clear that breeding adults may carry large helminth populations, with one of seven from marshes and six of twenty-three from potholes having more than 1,000 worms. Yet, of the 30 breeding adults, 13 had totals of less than 100 helminths. We thus note a pattern first evident in the wintering adults,

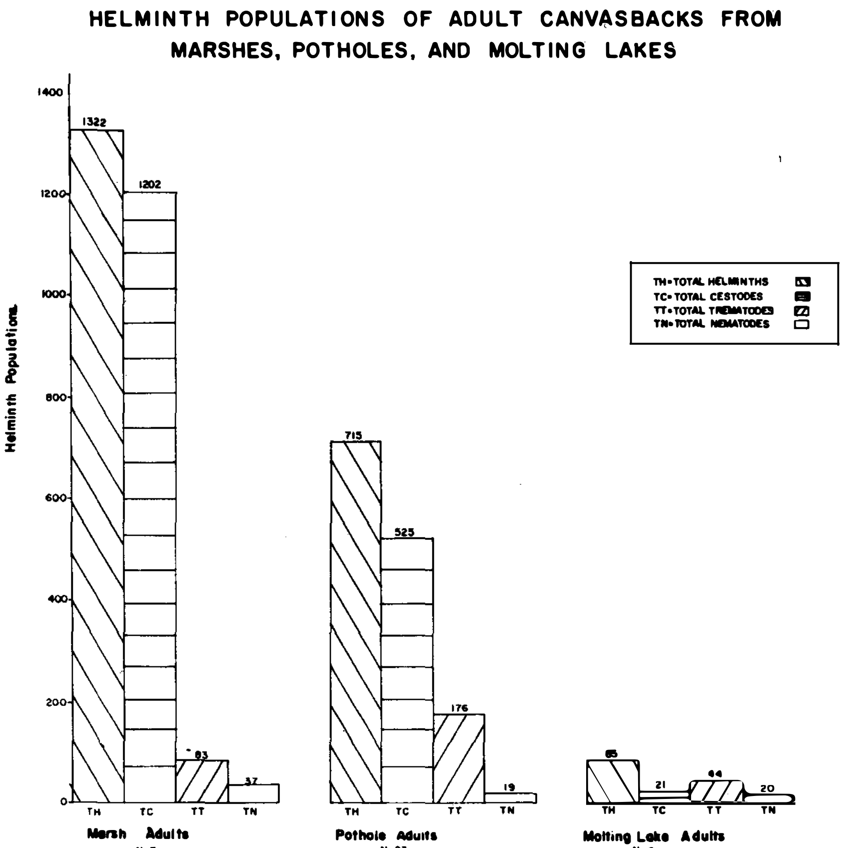

Figure 3. Helminth Populations of Adult Canvasbacks from Marshes, Potholes, and Molting Lakes.

that of a majority of canvasbacks with relatively low total numbers of helminths, and a few with massive infections.

Certainly, adult and immature waterfowl making an extended visit to the shallow, fertile prairie potholes and marshes enhance their opportunity to acquire helminths. These waters literally teem with animal food, and a history of prolonged waterfowl occupation insures the presence of infective invertebrates. It is not too surprising, therefore, to find ducklings with large helminth populations at an early age, especially since the adult canvasbacks may be so heavily parasitized.

The low incidence of helminths in the molting adult canvasbacks is extremely interesting. The altered behavior and the preferred environment of molting canvasbacks may partially explain the difference in helminth numbers. They tend to stay on the deeper water of northern lakes and bays, where the water physics and chemistry are probably quite different from the marshes and potholes. And they depend largely on selected vegetation for food, with animals playing a minor nutritional role. This is in direct contrast to adults in the pothole area, flying from water area to water area. The intestinal contents of ducks collected from potholes and marshes will include abundant and varied animal foods, especially snails, aquatic insects and crustaceans.

Three adult and three immature canvasbacks were shot on Lake Winnipegosis. Manitoba, in October, 1961. The adults of this sample are of particular interest because of a mean total of 12 helminths each, half of which were nematodes embedded in body tissues. Indeed, the intestinal tracts were essentially devoid of worms. We have a large sample of redheads (*Aythya americana*) collected at the same time, and they also have few or no worms in the intestinal tract! The intestines were greatly distended and filled with the alga *Chara* sp., in both canvasbacks and redheads. We suggest that, either through abrasion or chemical alteration of the intestinal chyme, this nearly complete dependence on *Chara* sp. serves as a natural means of deworming the host. At the same time, few invertebrates are eaten to initiate reinfection. The fact that the few helminths present were either embedded in tissues or living in sheltered locations, such as the ceca and folds of the cloaca, supports this theory.

Three immature birds, although shot at the same time as the above, were not as free of worms. Instead, they carried a mean intestinal cestode infection of 212. Their intestines were neither distended, nor filled with *Chara* sp. although some was present. The collectors, all experienced waterfowlers and including H. Albert Hochbaum, believed these birds to be new arrivals at the lake. In their experience, the resident adult birds are more wary and difficult to decoy, whereas this small group came immediately into the stand. The comparatively large helminth populations of these juveniles could be explained by their recent arrival at Lake Winnipegosis, or perhaps by differing food preferences. In either event, they further illustrate the great variation in the helminthfauna and its numbers, even among birds of the same species collected at the same time and place. Extreme differences exist between ducklings of one brood, where uniformity should be evident, if anywhere. Actually, a typical helminth population does not seem to exist in wild canvasbacks.

The Ducklings of Marshes and Potholes: The striking disparity between adults and ducklings has already been discussed and illustrated in Figure 1. In 1961, 36 ducklings of varying ages were collected from potholes in the vicinity of Minnedosa, Manitoba, and another 28 were taken in 1962. Comparison of the means of the 1962 group to those for 1961 is of interest; nematodes, 63±11:87±18; trematodes, 272±236:316±226; cestodes, 1068+334:2530+1148; acanthocephalans, 1±0.8:0.6±0.2; and total helminths, 1405±348:2933±1147. If the eight-week-old ducklings collected in 1961 with 40,138 cestodes is removed, the 1961 data closely approximate those of 1962, Figure 4. This approximation reflects a similarity of helminthfauna among pothole ducklings that does not appear to exist in nature. Pothole ducklings can be expected to have many immature ***Tetrameres*** spp., sometimes exceeding 400; and, *Gastrotaenia cygni* is frequently encountered under the gizzard lining. The cestodes include a variety of species and commonly number in the thousands. Although trematodes seldom attain the numbers reached by tapeworms, they are often present in hundreds and occasionally exceed a thousand. Acanthocephalans are rarely seen and when found are usually in ducks from the same body of water.

And still the unexpected is customary. Four ducklings collected from the same brood, seven to eight weeks old, had ***total*** infections ranging from 92 to 197, most of which were larval ***Tetrameres*** spp. How can such low infections be explained when the mean worm burden for their age group was 1,078±254? They were 100 grams heavier than other ducklings of the same age. Was this a result of the small numbers of intestinal helminths? A duckling less than one week old had 1,334 helminths, 1,283 of them trematodes, yet no worms could be found in a second duckling of the same age. A third duckling, ten days old, carried 5,500 helminths, two-thirds of which were tapeworms. Large trematode and cestode populations could be expected in the small intestine, with one-half of the ducklings having more than 1,000 worms. Nonetheless, 20 per cent of the entire sample had fewer than 250 helminths.

Examination of data in Table 2 and Figure 4 for ducklings collected on large Manitoba marshes reveals that, except for total nematodes, the 21 marsh ducklings were more heavily parasitized by all other major groups of helminths. Also, the total helminth burden was nearly twice that of the adjusted burden in pothole ducklings. The differences are even greater than the statistics would suggest, because half of the birds were less than three weeks old. These younger juveniles generally have lower worm burdens than the older juveniles, although they are still quite heavily parasitized

TABLE 2. PARASITE BURDENS OF THE CANVASBACK SAMPLES (MEANS AND STANDARD ERRORS)

Sample	No.	Mean Weight	Sex Male	Sex Female	Mean (x), Standard Error (S.E.x), and Range: Total Helminths	Total Nematodes	Total Trematodes	Total Cestodes	Total Acanthocephalans
Total Sample	180	......	108	72	1,444±253 (0-40,464)	42±22 (0-452)	281±42 0-4,695)	1,119±248 (0-40,138)	2.2±1.5 (0-20)
Total Adults	95	1,123	70	25	519±117 (4-4,707)	18±3 (0-219)	246±70 (0-4,695)	256±90 (0-3,302)	0.3±0.4 (0-6)
Total Ducklings	85	......	38	47	2,478±519 (0-40,464)	68±9 (0-452)	320±41 (0-1,869)	2,083±514 (0-40,138)	4.3±2.6 (0-20)
Detroit River "Normal"	43	1,141	40	3	194±67 (4-2,114)	15±3 (1-219)	153±53 (0-2,106)	11±18 (0-1,830)	....
Detroit River Diseased	16	872	16	......	912±380 (22-4,707)	16±4 (1-42)	874±383 (0-4,695)	22±13 (0-208)	....
Breeding Grounds Adults	36	1,213	14	22	733±249 (8-4,232)	22±3 (0-86)	128±37 (0-960)	584±232 (0-3,302)	0.9±0.8 (0-6)
Lake Winnipegosis Adults	3	1,465	2	1	12±1 (11-15)	6±2 (2-9)	2±0.4 (1-2)	5±2 (2-8)	....
Lake Winnipegosis Immature	3	1,536	3	......	212±68 (129-347)	33±8 (18-43)	2±1.7 (0-4)	175±76 (79-325)	2±3 (0-6)
Molting Lakes Sample	6	1,282	5	1	85±24 (10-163)	20±8 (6-58)	44±18 (0-93)	21±8 (1-58)	0.7±0.1 (0-2)
Pothole Ducklings	64	......	28	36	2,265±657 (0-40,464)	77±11 (0-452)	297±35 (0-1,545)	1,891±656 (0-40,138)	0.8±1.1 (0-20)
Marsh Ducklings	21	......	10	11	3,129±619 (26-8,538)	43±17 (1-370)	393±128 (11-1,869)	2,671±567 (3-8,376)	2.3±0.6 (0-8)
Ducklings from 1 Pothole	9	......	2	7	1,075±275 (0-2,524)	90±26 (0-221)	435±140 (0-1,367)	550±227 (0-2,180)	0.2±0.2 (0-2)
Ducklings from Same Brood									
Brood 1	4	992	1	3	139±27 (92-172)	91±18 (59-108)	24±7 (8-38)	24±3 (15-29)	....
2	4	957	2	2	1,757±506 (715-2,944)	30±2) (24-36)	159±16 (43-276)	1,568±487 (642-2,785)	
3	4	704	1	3	1,452±401 (636-2,524)	128±24 (82-188)	404±148 (153-814)	920±454 (218-2,180)	0.3±0.5 (0-2)
Ducklings of Varying Age									
0-1 weeks	7	65	2	5	41±17 (0-127)	2±2 (0-11)	29±12 (0-84)	9±4 (0-32)	0.6±0.4 (0-3)
1-2 weeks	1	161	1	......	5,500	41	1,869	3,590	....
2-3 weeks	10	321	4	6	1,894±660 (89-5,644)	24±3 (11-45)	451±192 (2-1,713)	1,418±491 (40-4,490)	1.3±0.8 (0-8)
3-4 weeks	4	376	2	2	1,071±355 (533-2,103)	28±6 (13-43)	632±315 (205-515)	412±71 (174-1,545)	....
4-5 weeks	5	539	2	3	1,480±411 (541-3,013)	35±16 (10-97)	515±120 (159-814)	930±500 (59-2,827)	0.4±0.2 (0-1)
5-6 weeks	9	710	5	4	1,718±416 (289-4,534)	42±8 (12-82)	185±90 (11-841)	1,487±368 (505-4,342)	4.4±2.2 (2-20)
6-7 weeks	7	759	3	4	4,282±1,315 (753-7,703)	99±47 (18-370)	351±165 (40-1,184)	3,830±1,341 (5-8,384)	 (0-6)
7-8 weeks	13	923	5	8	1,078±254 (92,2,944)	105±31 (24-426)	238±90 (6-1,072)	735±295 (25-2,785)	0.4±0.1 (2-3)
8-9 weeks	5	865	1	4	12,441±7,204 (1,487-40,464)	56±19 (14-116)	723±255 (60-1,367)	11,662±7,343 (106-40,138)	0.6±0.2 (0-1)
9-10 weeks	3	1,010	2	3	2,465±1,766 (487-5,988)	179±136 (31-452)	27±13 (3-45)	2,258±1,821 (421-5,901)	1.3±1.3 (0-4)
10-12 weeks	10	1,041	4	6	1,708±172 (90,4,833)	83±25 (21-243)	248±103 (0-829)	1,378±541 (3,4,653)	0.4±0.4 (0-4)
12+ weeks	7	1,301	6	1	1,584±1,107 (129-8,190)	101±40 (18-317)	10±4 (0-26)	1,471±1.098 (79-8,025)	1.8±0.2 (0-6)

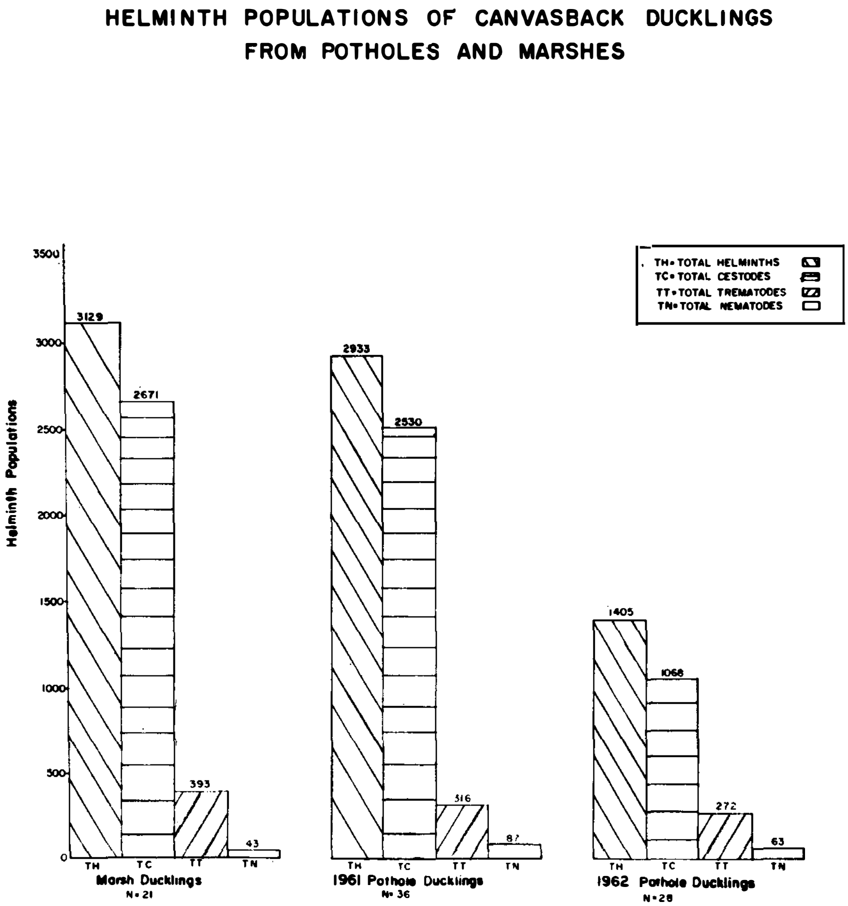

Figure 4. Helminth Populations of Canvasback Ducklings from Potholes and Marshes.

when contrasted to adults. We believe, on the basis of many days of field observations, that the large, shallow, and fertile marshes provide the ultimate in opportunity for acquisition of helminths. Aquatic insects, mollusks and crustaceans abound in these waters, and their chitenous remains sometimes filled the intestines of the waterfowl necropsied.

Duckling from the Same Potholes: Nine ducklings were collected on a Manitoba pothole (Moorepark, T 13 N, R. 18 W., the south edge of Section 5) and were analyzed for variations between ducklings (Figure 5). In one duckling less than a week old, no helminths were

HELMINTH POPULATIONS OF NINE DUCKLINGS FROM A SINGLE POTHOLE

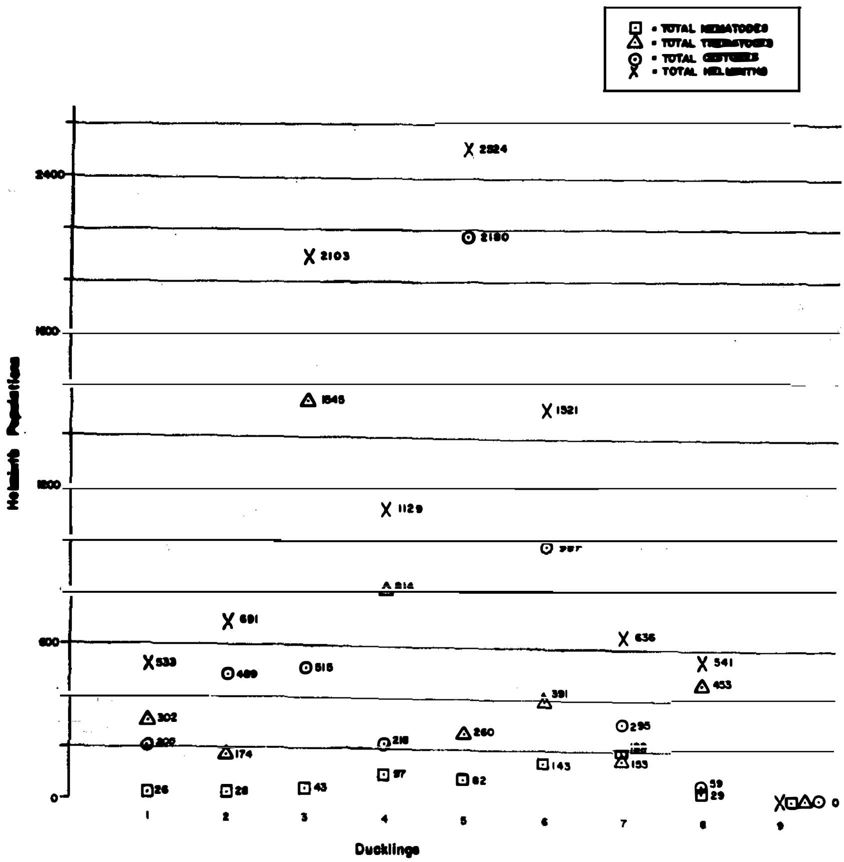

Figure 5. Helminth Populations of Nine Ducklings from a Single Pothole.

found. The infected ducklings were grouped in the following age classes: 3-4 weeks (3), 4-5 weeks (2), 5-6 weeks (1), 7-8 weeks (2). The effect of age on the size and composition of helminth populations is not clear. However, ducklings under two weeks in age have smaller parasite loads than the majority of older birds.

Three ducklings from the same brood, 24-28 days old, harbored surprisingly different helminth numbers. One of these had a total worm burden (2,103), four times as large as the others (691 and 533). Although nematode populations were similar in composition and numbers (26, 28, and 43), the heavily infected duckling had five times as many flukes (1,545), mostly strigeids, as his brood mates (302 and 174). Another in the brood harbored only one-half the cestode burden (205) found in the other two (515 and 489).

A duckling from a second brood on the pothole also carried a large worm burden (2,524), which this time was comprised mainly of cestodes (2,180). We found two acanthocephalans in this same duckling, the only bird from the pothole to be infected with these parasites.

There are, however, interesting similarities in the infections. *Echinuria* sp. and *Streptocara* sp., neither particularly common parasites, were recovered from four of these ducklings. Six of them had *Gastrotaenia cygni* infections under the gizzard lining, and all eight parasitized ducklings harbored notocotylid trematodes in the ceca, often in numbers exceeding 50. Echinostomes were found in all eight parasitized birds, and seven of them harbored large infections of strigeids. Schistosome infections were detected by the presence of eggs in four of the nine ducklings. *Typhlocoelym cymbium* was recovered from the lungs or body fluids of three ducklings. The estimated number of helminth species per duckling varied from 11 to 18, with a mean of 15.

On the basis of this sample, ducklings from the same pothole may have similarities in the species composition of their respective helminthfauna, but helminth numbers will vary considerably within the group. We could not, after necropsying eight ducklings of the same species from this one small pothole, predict with any degree of certainty the species and numbers of helminths which would be present in the ninth specimen examined.

Ducklings from the same Brood: Differences between ducklings of one brood were of the same nature and magnitude as those between ducklings of the same pothole. Data summations of three broods of four ducklings each may be seen in Table 2. Nearly all ducklings in these broods were seven to eight weeks old, and each brood was from a different pothole. Is the heterogeneity of their helminth populations a result of occupying different water areas? Perhaps; but the complete answer awaits study of the invertebrate populations which serve as intermediate hosts for the parasites and as food for the ducklings. If the invertebrate assemblages vary significantly between potholes, the helminthfauna will vary accordingly. However, variations within the same brood and within ducklings from the same pothole suggest that other factors are also operating.

Brood One was the most homogenous sample studied. Cestode populations were nearly identical. Total helminth numbers in all four ducklings were low. Nematodes comprised more than one-half of the total worms present in each. Only one of the brood had ***Echinuria*** sp. in the proventriculus, and a second had two strigeids in the small intestine—the only trematodes in the small intestines and the only strigeids in the entire brood. A third duckling harbored the lone acanthocephalan. Trematodes of the large intestine and ceca varied widely among individuals.

Members of Brood Two harbored worm burdens varying from less than one thousand to three thousand. Tapeworms in the small intestine contributed the majority of the worms present. Echinostomes, gastrotaeniids, notocotylids, and schistosome eggs were observed in all four ducklings. Strigeids, typhlocoelids, and cecal capillariids infected three of the four brood mates. Thus, in this brood, both a similarity in the composition of the helminth population and a variation in the number of individuals representing each species was apparent. This may also be applied to Brood Three. The similarities in infections within broods suggest that all ducklings feed at the same table and taste the same dishes. But they certainly do not concentrate equally on the same foods. The duckling with 2,000+ tapeworms and very few trematodes likely has food preferences different from those of the duckling with nearly a thousand flukes and very few cestodes.

Ducklings in Different Age-classes: An objective of our research was to study the relationship of age to helminthfauna. Eighty-five ducklings were grouped into weekly age classes, with the exception of the ten to twelve and twelve plus weeks categories. Ducklings were collected on many different water areas. Thus, the effects of parasitism resulting from exposure to different ecological situations is superimposed upon the age-helminth population relationship, and may obscure it. In an age relationship study, ducklings of different ages should, ideally, come from the same pothole or marsh. Nonetheless, grouping these immature canvasbacks by age does yield some interesting results (Figure 6).

Ducklings in their first week acquired only a few helminths which were observable at necropsy (0-127), and trematodes were the most common of these. Only one duckling of the one to two-week age-class was taken, and it had already acquired 5,500 helminths (3,590 tapeworms and 1,869 trematodes). While this is a most interesting example of the massive infection a young duckling can acquire early in life, it cannot be considered representative of the age-class.

In the two to three-week age class and beyond, the extreme varia-

HELMINTH POPULATIONS IN DUCKLINGS OF DIFFERENT AGES

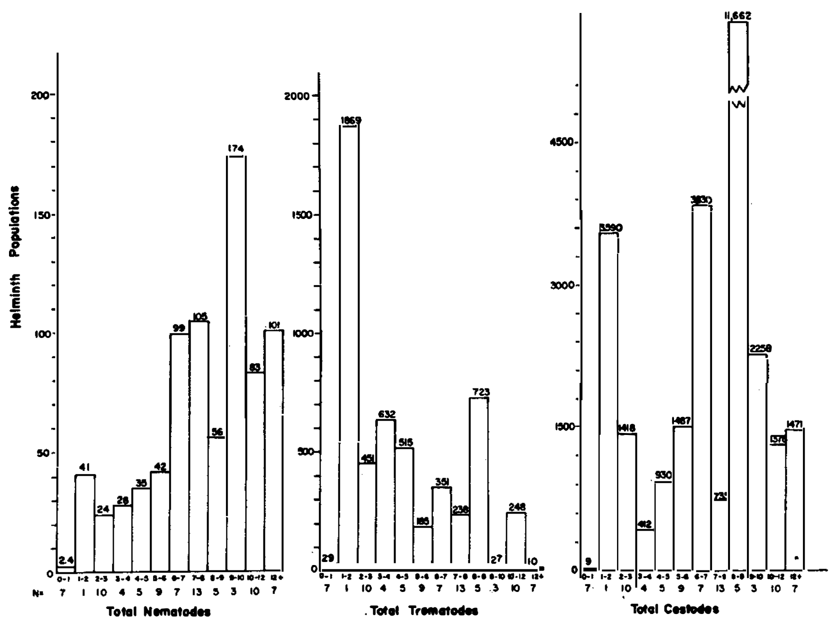

Figure 6. Helminth Populations in Ducklings of Different Ages.

bility of helminth numbers, evident throughout our study, makes analysis of the data difficult. In this sample of ten ducklings, six had total parasite burdens ranging from 1,000-6,000. The remaining four ducklings carried worm loads of less than 500, and one of these had only 89 worms! In some specimens cestodes constituted the majority of worms present, and in others trematodes were more numerous. It is clear that a three-week-old duckling may be either very heavily (5,644), or very lightly (89) parasitized.

The number of nematodes per infection build up gradually, and infections of over 100 were not seen in ducklings less than six weeks old. In the six to seven-week age-class the nematode infections ranged from 18 to 370.

The largest mean total helminth population was in the eight to nine-week class (12,441). A duckling with 40,464 helminths, mainly tapeworms, was in this group. When this individual was rejected, the mean for the group still exceeded 5,000 and was the largest of any age interval. As the age of ducklings increased beyond nine weeks, the worm burden declined slightly. Birds over twelve weeks old had a mean total of 1,500 helminths. Four of this sample, however, had helmonth populations numbering less than 500, and only two exceed-1,000.

It may be that certain extrinsic and intrinsic changes in host biology result in a lowered helminthfauna shortly before the fall migration. Before any firm conclusions are drawn on the age-helminth population relationship, larger samples of ducklings in the respective age classes are needed.

ECOLOGICAL CONSIDERATION OF THE CANVASBACK AND ITS HELMINTHS

The canvasback, shortly after hatching from the egg, begins to seek its own food. These foods are, in the early weeks of its life, principally invertebrate animals which also act as intermediate hosts for most helminths. The water area near the nest becomes the source of the duckling's first invertebrate food and thereby its first helminths.

The number of infective worms in a particular ecosystem depends upon many factors. A variety of invertebrates are necessary to serve as intermediate hosts for many species of parasites. Also the chance of duckling infection is controlled by the number of other waterfowl which are seeding the area with helminth eggs. A body of water used by thousands of ducks, such as a large marsh, will probably contain many invertebrate animals bearing infective stages of a great variety of helminth species.

The duckling's initial helminth infection is determined, then, chiefly by the selection of a nest-site by the hen. The ducklings which live their first weeks on a small, isolated pothole that does not attract many ducks are likely to have few helminths. If a pothole has a small snail population, or has only snail species that do not enter into trematode life-cycles, the ducklings living thereon will have a low trematode infection rate.

When canvasback ducklings are about three weeks of age, they frequently follow the hen across country from the rather small natal area to a larger pothole or lake (Evans, 1952). Ducklings gather here in flocks, sometimes numbering more than one hundred, with several adult females accompanying them. On these larger water areas, the juvenile canvasbacks associate with more adults which are probably passing viable helminth eggs. Also, these areas are attractive stop-over sites for migrating ducks which in the course of their stay, add representatives of their own helminthfauna to the ecosystem.

At ten weeks, ducklings are able to fly and begin to visit many nearby water areas, thereby potentially adding additional species and numbers of heminths.

The duckling, however, never acquires large numbers of helminths which live in and feed on its tissues. Populations of worms in the upper digestive tract, the ceca, cloaca, lungs, kidneys, and other such organs remain small and relatively constant when present. It is the cestode and trematode populations of the small intestine that sometimes exceed 40,000 and demonstrate extreme variability among individual hosts. Undoubtedly, tissue-feeding helminths initiate an immune response by the host. This defensive mechanism increases the canvasback's resistance to subsequent infections by the species initiating the response. Finding immature *Tetrameres* spp. throughout the lower digestive tract of an already heavily infected duckling seems to indicate that these worms were unable to establish themselves in the proventriculus and were probably being excreted. Helminths are also subject to intraspecific competition. This mechanism operates through the excretion of metabolic products by established parasites. These products may either prevent the establishment or inhibit the growth of subsequently ingested helminths of the same species.

The food preferences of individual ducklings may well be the major factor controlling the kinds and numbers of intestinal helminths whose infective stages are present in the ecosystem. Collias and Collias (1958 and 1963) have reported the selective feeding by ducklings of different species. Food preferences of ducklings may be extremely variable. To illustrate this point, a number of actively feeding ducklings from the same brood were collected at the same time. Examination of the contents of the upper gastro-intestinal tract showed one to have fed on snails, a second largely on aquatic insects, and a third on vegetation. It may be that a duckling acquires a preference early in life for a certain group of similar food items and searches selectively for that kind of food.

Those female canvasbacks which remained on the breeding areas with their ducklings either acquired, or already had, the same helminth species. However, their helminth burdens were considerably smaller than those in ducklings, but larger than in all other adult samples.

Non-breeding and post-breeding canvasbacks gather on the large, often more northern, lakes. There they undergo the molt in the comparative safety of open water. The amount of animal food available in that environment may be quite small, and the ducks seem to feed primarily on aquatic plants taken off the bottom. The birds from such habitats had the lowest worm burdens encountered.

The canvasbacks from these lakes in the early fall were at the greatest weight and had the lowest helminth populations of any examined.

When ducklings reach about twelve weeks of age, they customarily abandon the breeding areas and gather on the larger lakes prior to the fall migration. There they probably feed primarily on vegetation and eliminate the majority of the helminths living in the lumen of the gut.

The helminthfauna of migrant and wintering canvasbacks depends, in large part, on where they stop, how long they stay, and the foods available to them. Since the Detroit River canvasbacks were the only wintering population studied, we must draw our conclusions from the birds collected there. Canvasbacks wintering on the Detroit River usually concentrate around the beds of wild celery (*Vallisneria americana*). Over-wintering snails are abundant in these same food beds; and, as might be predicted on the basis of the animal foods available to them, echinostome and strigeid trematodes are their most common parasites.

THE EFFECTS OF HELMINTHS UPON THE HOST

In most cases, the role of helminth parasites in the causation of disease, and possibly death, is difficult to evaluate. Relatively small numbers of the tissue destroying helminths can cause death if not arrested by an effective immune response, or an intraspecific competition mechanism. On the other hand, the massive populations of tapeworms in ducklings (40,000+) seemed to produce no ill effects which were detectable at necropsy. More elaborate and sensitive study is needed to evaluate the effects of these intestinal helminth populations in ducklings. Under favorable nutritional conditions, the attrition resulting from helminths that derive their nutrients from the contents of the gut is likely to be small. The importance of intestinal worms as mortality factors is probably limited except under conditions of severe host stress when the nutritional requirements of the host and its parasites come into conflict.

The "old school of thought" which maintained that helminths seldom seriously harm the host seems to be losing adherents. There are numerous reports in the literature which cite helminths as being the primary cause of waterfowl deaths. We have encountered several cases of mortality in ducklings where death could be attributed to infection of the proventriculus by *Echinuria* spp. *Spaeridiotrema globulus*, a cecal trematode, has caused death in experimental and wild canvasbacks. Large populations of strigeids and echinostomes in canvasbacks on the Detroit River, during periods of apparent food shortage and prolonged cold, have resulted in enteritis, intestinal hemorrhage and death.

Parasites and their relationship to their host are interesting zoological phenomenona which must be much better understood if we are to know the host. We must know their effects upon the host if we expect to properly evaluate their role in the population dynamics of the host species.

ACKNOWLEDGMENTS

For the financial support that has made this study possible, we wish to express our appreciation to the Wildlife Management Institute, the Delta Waterfowl Research Station, the Frank M. Chapman Fund of The American Museum of Natural History, the National Wildlife Federation, and the Game Division, Michigan Department of Conservation. The senior author also wishes to acknowledge the assistance of Schoen-Rene Fellowships received through the School of Natural Resources, The University of Michigan, and of Predoctoral Fellowships from the National Science Foundation.

Many individuals contributed to the project, foremost among these are Mr. H. Albert Hochbaum, Dr. George S. Hunt, Mr. Peter Ward, and Mr. James Foote. The following student assistants in the Department of Wildlife Management, The University of Michigan spent many hours in necropsy and microslide preparations: Jerry Longcore, Dennis Murphy, Rolf Hartung, Patrick Kennedy, Warren Blandin, John Schmid, Edward Schlatter, and the late Allan Schultz. The work could not have gone forward without their steadfast interest in the research program.

SUMMARY

Necropsies were made of 180 wild canvasbacks, the sample including 95 adults and 85 ducklings collected from the Detroit River and Manitoba potholes and marshes. All of the internal organs were examined for cestodes, trematodes, and nematodes. The distribution of helminth populations within the hosts are discussed, and comparisons made between the various samples collected at different locations.

Canvasbacks collected on the Detroit River in a diseased condition had nearly five times as many helminths as their "normal" counterparts collected at the same time. Apparently "normal" breeding ground adults were nearly as heavily parasitized as diseased canvasbacks taken on the Detroit River, although cestodes were by far the most common in the former and trematodes in the latter. Adults from "molting" lakes, and especially those feeding on large amounts

of the alga *Chara* sp., were almost entirely free of intestinal helminths.

Ducklings carried five times as many helminth parasites as adults. Ducklings collected from marshes were more heavily parasitized than those from potholes. Great variations were observed in the helminthfauna of ducklings from the same pothole, and even from the same brood. Ducklings of the same brood, however, had certain similarities in the species composition of the helminthfauna, and it is theorized that the large differences in numbers of helminths reflect food preferences of individual ducklings. In comparing ducklings of different ages, it was apparent that large numbers of helminths were present by the second week of life, and that the majority of these were tapeworms. There is some indication that peak helminth populations are reached in ducklings eight to nine weeks old, and that by the twelfth week their numbers begin to decline. The various factors which combine to produce the helminthfauna of wild canvasbacks are discussed.

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DISCUSSION

DR. MALCOLM MCDONALD [Bear River Research Station, Utah]: You showed a difference between potholes and marshes here. Did you make any studies to see a demonstrated difference in the variety of invertebrates on the potholes and marshes?

DR. CORNWELL: Yes. We have—I say *we* to include Mr. Bartonek's study, and we hope to collaborate at some future date. It does seem that there are variations in the invertebrate populations and that these cause variations in the helminthfauna. However, you get such a tremendous variation in the helminthfauna from birds of the same water area with the same invertebrate population that I'm rather doubtful that we'll get very much by comparing different areas.

DR. MCDONALD: The other question. In these molting areas, did the gizzard worm population hold up in molting birds?

DR. CORNWELL: Molting canvasbacks go to very large lakes and usually stay in deeper water and apparently feed almost entirely on vegetation—and the only worms that did hold up at all were the tissue nematodes and a few worms and seeds in the folds of the cloaca. In a sense, anything that wasn't embedded in deep tissue was flushed out.

DR. MCDONALD: That would include the gizzard worms? That was the point I was going to make.

DR. CORNWELL: Yes, they did have gizzard worm infections but they weren't heavy.

DR. MCDONALD: I might mention that in regard to loss of worms, we found the same thing in mallards. As they shift from invertebrates to more plant food, they also seem to lose the high helminth population, as George indicated here.

DR. CORNWELL: Yes. In the canvasback duckling the decline in helminths begins usually after the ninth week.

A VOICE: Mr. Speaker, in your discussion you refer to diseased birds, and you implied that there were more worms in diseased birds. What is your criterion of diseased birds?

DR. CORNWELL: That is an excellent question and I tried to answer it in this paper. The best way that we have of answering it is telling what we think is a healthy bird, and we use "normal" throughout. These are canvasbacks in the wintering area that are going about their normal business; they're flying, they're feeding, when we get them. They are generally of a good weight, almost always. They're three-quarters of a pound to a pound heavier than what we think of as a diseased bird. The diseased birds are moribund and they're usually up on shore. They may have died recently, although frequently they crawl into people's backyards and are picked up for us while they are still alive. It is difficult to separate them, other than by that subjective basis.

LEPTOSPIROSIS IN ONTARIO CERVIDAE

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White-tailed deer (*Odocoileus virginianus*) are recognized hosts for pathogenic leptospirae. Serologic surveys of the deer herds in several of the United States have revealed leptospiral antibodies in varying numbers of the animals tested; ranging from rather low percentages in some areas (Shotts *et al.*, 1958) to a high of 26 per cent of 1256 deer tested in Wisconsin (Trainer *et al.*, 1963).

Leptospira pomona appears to be the most common leptospiral serotype in deer, although several investigators have obtained serologic evidence of infection with other serotypes (Ferris *et al.*, 1961; Trainer *et al.*, 1963). There are, however, relatively few reports of cultural isolation and identification of leptospirae from deer. All strains isolated to date have been *L. pomona*. Reilly *et al.* (1962) were first to isolate *L. pomona* from a naturally-infected white-tailed deer; from the urine of an animal killed in a special mid-winter hunt in New York State.

Leptospira pomona was isolated from kidney tissues of four white-tailed deer in Ontario in 1961 (Abdulla *et al.*, 1962). These were 4 of 15 deer collected in the vicinity of bovine outbreaks of leptospirosis. Of the 15 animals, only one was without antibody to *L. pomona.* The present paper deals with an extension of the survey for leptospirosis in the Cervidae of Ontario, employing techniques of serology, histopathology and cultural isolation. The observations reported were made during the period February, 1962 to January, 1963.

METHODS

Specimens were obtained by shooting deer in the vicinity of outbreaks of leptospirosis in cattle, by making use of hunter-killed deer and moose (*Alces americana*) during the regular hunting seasons, and by using the carcasses of animals accidentally killed on highways and those taken in a herd control program in a provincial park. Blood, collected from the hearts, large vessels, or thoracic cavities of deer and moose was utilized to provide serum for testing by the microscopic-agglutination test, using live antigens (*L. pomona, L. grippotyphosa, L. icterohaemorrhagiae*). Kidneys were collected whenever it was possible to obtain them fresh, undamaged and free from gross contamination. These were usually held on wet ice or in a refrigerator at about 4° C until they could be examined, or where storage longer than a day or two was required, they were frozen quickly and maintained at low temperatures until processed. Small pieces of kidney tissue were fixed in 10 per cent formalin, sectioned and stained with hematoxylin and eosin for histologic examination. Kidney tissues were examined for leptospirae by inoculation of tissue suspensions into tubes of Korthoff's medium. Details of the cultural and serologic methods have been published elsewhere (Abdulla *et al.*, 1962).

In some cases where pregnant females were obtained, fetal fluids and tissues also were examined for the presence of leptospirae.

OBSERVATIONS

Serology

Agglutinins to *L. pomona* were found widely distributed in deer throughout agricultural Ontario. More interesting, evidence of leptospirosis was found also in deer and moose in parts of Ontario which do not have cattle and swine, the recognized domestic animal hosts of *L. pomona.* Such an area is South Canonto Township, Frontenac County, where 5 of 11 deer had antibody to *L. pomona;* also the Kenora District where 4 of 58 moose possessed significant levels of *L. pomona* agglutinins. These data are summarized in Figure 1 and in Tables 1 and 2.

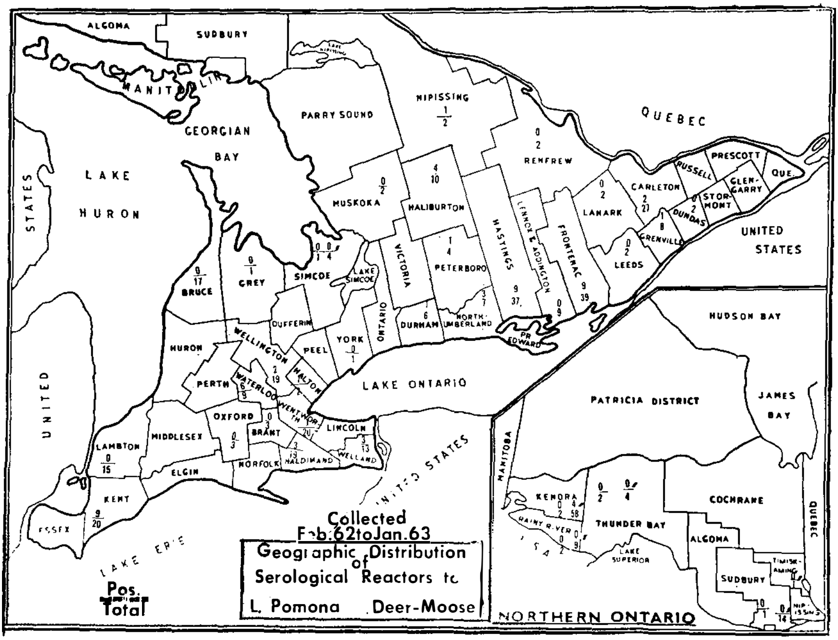

Figure 1. Geographic distribution of deer and moose sera tested for antibody to *Leptospirae*. The number of animals with *L. pomona* antibody are designated as numerator, over the total number tested, as denominator. Moose sera are indicated with a prime sign (e.g. 4/58′).

Histopathology

Kidney lesions suggestive of leptospirosis (Trainer *et al.*, 1961) were found to correlate in most instances with the presence of serum agglutinins in the animals examined. There were exceptions, however. Four of 17 deer from Bruce County, Ontario, were found to have marked interstitial nephritis in the absence of serological titers to the 3 leptospiral antigens used. Presence of kidney lesions without demonstrable antibody to leptospirae (with the antigens used) were found also in a few deer in other parts of the province.

Isolation of Leptospirae

Leptospira pomona was isolated from the kidney tissues of a female white-tailed deer, approximately 1 year of age, which sustained a spinal injury from some unknown means on the outskirts of the city of Kitchener, Ontario, on May 25th, 1962. The animal was pregnant with a fetus 330 millimeters in length, suggesting a fetal age of approximately 10 days (Armstrong, 1950). The fetus was not examined at once, however, but was deposited in the unopened uterus

TABLE 1. RESULTS OF EXAMINATIONS FOR LEPTOSPIROSIS OF WHITE-TAILED DEER AND MOOSE TAKEN IN ONTARIO IN 1962

Species	Serology[1]	Kidney Lesions[2]	Leptospiral Isolations
White-tailed deer	56[3]/310 (*L. pomona*)	43/170	3/142 (*L. pomona*)
Moose	4/9● (*L. pomona*	0/0	0/0

[1]Highest serum dilution giving 50 percent or greater lysis in the microscopic agglutination-lysis test, employing 3 antigens (*L. pomona, L. icterohaemorrhagiae* and *L. grippotyphosa*).
[2]Interstitial nephritis, suggestive of leptospirosis.
[3]Number of animals positive (numerator) over number of animals tested (denominator).

TABLE 2. RESULTS OF EXAMINATIONS FOR LEPTOSPIROSIS OF WHITE-TAILED DEER TAKEN IN RONDEAU PARK, ONTARIO, JANUARY, 1963

No. of Animals	Sex	Age	Serology[1]	Kidney Lesions[2]	Leptospiral Isolations
5	male	½-6½	—	—	—
1	male	½	1/1620 (*L. pomona*)	+	+ (*L. pomona*)
1	male	½	1/540 (*L. pomona*)	+	Not examined
3	male	1½-7½	1/180 (*L. pomona*)	—	—
5	female	½-6½	—	—	—
2	female	½-4½	1/540 (*L. pomona*)	+	—
2	female	7½-8½	1/180-1/540 (*L. pomona*)	—	—

[1]Highest serum dilution giving 50 percent or greater lysis in the microscopic agglutination-lysis test, employng 3 antigens (*L. pomona, L. icterohaemorrhagiae* and *L. grippotyphosa*).
[2]Interstitial nephritis, suggestive of leptospirosis.

in a refrigerator, maintained at approximately 4° C. The fetus was examined only when it was found, 11 days later, that leptospirae had been isolated from kidneys of the dam. Serum from the dam, obtained at necropsy, possessed a titer of 1/4860 to *L. pomona* by the agglutination-lysis test. Necropsy of the fetus, performed after 11 days storage in the refrigerator, exposed a liver that was studded on its surface and throughout its substance with yellowish necrotic and hemorrhagic lesions, each about the size of a 10 cent coin. Small whitish indistinct lesions were present in the cortex of the kidneys. A 1/1000 dilution of ground tissues from this liver inoculated into Korthoff's medium produced growth of leptospirae visible after five days of incubation at 30° C. Organisms were visible by dark field microscopy in tubes of the medium inoculated with 1/10,000 dilutions of liver tissue suspension of the eigth day of incubation. Similarly, leptospirae were observed in medium inoculated with a 1/1000 dilution of kidney tissues from this fetus at 12 days incubation. Bacterial organisms were not demonstrated by inoculation of blood agar plates and thioglycollate broth, incubated aerobically, anaerobically and under 20 per cent CO_2. This isolate, provisionally identified in our laboratory as *L. pomona,* was submitted for typing to D. A. D. Alexander of the World Health Organization Leptospirosis Typing

Center at Walter Reed U.S. Army Hospital, Washington, D. C. Its identity as *L. pomona* was confirmed by microscopic agglutination tests employing a large battery of antigens.

The city of Kitchener is surrounded by an intensive mixed farming area. Leptospirosis had been diagnosed frequently in cattle and swine in the area the previous fall but not since the winter months (Abdulla *et al.*, 1962).

It was not determined that the deer fetus in this case was alive when the dam was killed. The well-preserved state of the fetus after 11 days refrigeration would suggest that the fetus was alive at the death of the doe. The extensive liver lesions, however, would appear to support the view that death of the fetus was impending and if delivered it would have been born dead or would soon have died.

Leptospirae were isolated also from the kidneys of 1 of 19 deer collected by shooting in Rondeau Park, Ontario, in January, 1963. This isolate has been provisionally identified as *L. pomona* in our laboratory. Since the animal was a male fawn, only about 8 months of age, its agglutinin titer of 1/1620 to *L. pomona* must represent infection acquired in the latter part of 1962. Renal lesions present were those of severe focal interstitial nephritis. As pointed out in an earlier paper by Abdulla and others, (1962) Rondeau Park is a peninsular area, without cattle or swine but from which there is considerable movement of deer to and from adjacent farming areas. Leptospirosis had not recently been a recognized disease in livestock in the vicinity.

DISCUSSION

In pointing out the occurrence of serologic titers to *L. pomona* in deer and moose in parts of Ontario which do not have populations of domestic livestock, we do not mean to imply that deer and moose are themselves capable of acting as long-term reservoirs or maintenance hosts of the leptospirae. Present evidence does not justify this assumption. Evidence from experimentally-induced leptospirosis suggests that the white-tailed deer may react much like the cow to leptospiral infection, responding with a short period of leptospiremia followed by a period of six weeks or so during which leptospirae may be isolated from the urine (Reilly *et al.*, 1962; Roth, 1962; Trainer *et al.*, 1961). Pregnant females may abort. While urinary shedding is evidence of the renal carrier state, maximum duration of this carrier state has not been definitely established. Since there is usually a prompt immune response following the leptospiremic phase, the presence of antibody may have interfered with attempts to isolate leptospirae from urine and kidneys (Trainer *et al.*, 1961).

It is possible that leptospirosis in deer may be dependent upon a source of infection in other wildlife species. Raccoons in Ontario have been found to have a high infection rate (Abdulla *et al.,* 1962) and skunks are not only highly susceptible but they can remain renal carriers of *L. pomona* for long periods of time, sometimes without reducing serum agglutinins (Abdulla *et al.,* 1962; Roth, 1962). Such animals would appear to be more likely candidates than deer as true maintenance hosts for *L. pomona.*

Isolation of *L. pomona* from deer in the areas where livestock are not known to be involved and the high rate of serological reactors in some of these areas would suggest that deer are, in their normal behavior, close to a source of infection in nature. How much deer themselves serve to perpetuate the infection within the deer herd remains to be determined. High infection rates have been found in deer in the vicinity of bovine outbreaks, yet the fact remains that deer have been found infected months after the last known bovine cases in these districts (Abdulla *et al.,* 1962). The direct relationships, if any, between leptispiral infections in cattle and deer are not known. It seems quite possible that epizootics in both cattle and deer may be initiated by infection from some common source. It is perhaps logical to assume that once established in the deer or cattle herd, there will be at least some deer-to-deer or cow-to-cow transmission. Trainer *et al.* (1963) have suggested that direct deer-to-deer transmission of leptospirae may occur, perhaps facilitated by breeding behaviour or by contacts between animals during the yarding period. Much remains to be done in the study of enzootic foci of leptospirosis in nature. Such forms of life as reptiles have only begun to receive attention as possibly important natural hosts of leptospirae (Abdulla *et al.,* 1963 White, 1963).

Little is known of the occurrence of leptospirosis in moose. To our knowledge we have encountered the first evidence of the infection in this species. Serological titers are, at best, tenuous evidence of infection. Further evidence may be provided by histopathologic examinations and isolation of leptospiral organisms. Certainly the semi-aquatic habits of moose would appear to make them highly subject to exposure in areas where renal carriers may contaminate natural waters with leptospirae. Animals such as beaver must also be examined.

Experimental work, now underway, has shown that a moose has become infected with *L. pomona* through exposure to contaminated water and that antibody responses and urinary shedding of leptospirae occur much as they do in the white-tailed deer.

The finding of kidney lesions in deer from Bruce County and from other areas which did not possess antibody suggests one of three or more possibilities: (1) That the animals were infected with a serotype of leptospira other than *pomona, grippotyphosa* or *icterohaemorrhagiae;* (2) That leptospiral infection did not stimulate an antibody response. (This phenomenon has been recognized in other wild species); or (3) That the kidney lesions, constituting an interstitial nephritis, were caused by agents other than leptospirae. It is our intention to subject sera from animals which had kidney lesions suggestive of leptospirosis and which dd not have agglutinins to the antigens used in our tests, to a testing procedure utilizing a larger number of leptospiral serotypes.

SUMMARY

Serologic evidence of infection with *Leptospira pomona* has been found in deer (*Odocoileus virginianus*) and moose (*Alces americana* widely distributed in Ontario. Antibody in animals in areas devoid of farm livestock point to a source of infection in nature. The possible role of Cervidae as maintenance host of *L. pomona* is not defined. *Leptospira pomona* was isolated from a naturally infected white-tailed deer and also from her diseased fetus.

ACKNOWLEDGMENTS

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DISCUSSION

DR. D. H. FERRIS [Illinois]: I didn't get your reactor rate from the serology.

DR. MCGOWAN: I haven't worked this out in percentages, but we did have 56 reactors out of three hundred and ten deer. And four in the 90 moose.

DR. FERRIS: I had a second question. Was there any evidence of any other infection in these deer?

DR. MCGOWAN: No.

PROFESSOR DAVIS: I would like to direct a question to Dr. Trainer. I know he has worked in this area. I notice that Dr. McGowan mentioned the fact that they just isolated the strain *L. pomona*. How about your work? Do you have anything to add in this regard to other strains?

DR. TRAINER: No. Actually we think *pomona* is the one that is involved, although we have serologic evidence that others may be involved.

I did have a couple of questions, too. Since you isolated the organism from the fetus and you assume that this fetus would probably have died or been aborted, would you care to comment on the significance of this? Is this a problem in the wild?

DR. MCGOWAN: The only thing that I can say to this is that we have evidence that it does occur and that unborn fawns may contract *Leptospirosis.* We know from your work, Dan, that you have produced abortions experimentally in your white-tailed deer herd. It does occur experimentally. We have found it occurring naturally. More work has to be done on this aspect.

DR. TRAINER: Would you care to describe the experimental set-up for your exposure of moose to *Leptospirosis?*

DR. MCGOWAN: This is unpublished data. This was a single moose calf, which was in the same pen as our white-tailed deer herd which we exposed, and in which we try to simulate natural conditions. We infected the moose by letting her drink and paddle in contaminated water, water inoculated with *Leptospirae.* The moose was definitely infected, as I have said in my paper, and in the future, work on the deer herd will be reported.

COCCIDIOSIS—INCIDENCE, EPIZOOTIOLOGY IN TWO WISCONSIN SCIURIDAE[1]

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During the summer months of 1961 and 1962, coccidiosis was studied in two Wisconsin Sciuridae, the Eastern chipmunk (*Tamias striatus*) and the red squirrel (*Tamiasciurus hudsonicus*). These host animals were selected for study because of their abundance, the absence of hunting restrictions on them, and the ease with which they can be live-trapped. Since coccidiosis is an important cause of unthriftiness and death in cattle and poultry (Anon, 1956 :314-317, 437-441), much research effort has been devoted to its study in domestic animals. In wild animals however, little study has been devoted to this protozoan disease.

Bull (1958) and Mykytowycz (1962) in New Zealand and Australia have carefully studied natural infections of coccidiosis in wild rabbits (*Oryctolagus cuniculus*). Doran (1953) in California, trapped various desert and semi-arid rodents and investigated the disease in these hosts under both natural and laboratory conditions. In this report, the incidence and abundance of four species of coccidia (*Eimeria*) were studied, *E. vilasi* and *E. wisconsinensis* in the chipmunk, and *E. tamiasciuri* and *E. toddi* in the red squirrel.

METHODS

A 12.2 acre study plot of second-growth white and red pine (*Pinus strobus* and *P. resinosa*), yellow and white birch (*Betula lutea, B. papyrifera*) and hard maple (*Acer saccharum*) located at the University of Wisconsin Biological Station on the east shore of Trout Lake, Vilas County, Wisconsin was selected for study. Live-trapping with small sheet-metal box traps was conducted on this area over a 4-day period at monthly intervals throughout the two summers. After each animal was trapped, the live-trap was scrubbed and rinsed to prevent the transmission of coccidiosis from feces in the trap. To augment the monthly samples, additional animals were shot within a three-mile radius of the study area. All animals live-trapped on the study area were examined, ear-tagged and released. Many were then later recaptured.

From each animal, a fresh .05 gram fecal sample was obtained. Each sample, placed in a small fermentation tube containing 2.5 per cent potassium dichromate, was then refrigerated until microscopi-

[1]Financed by NSF Grant GS 3703. The dedicated assistance of Mr. Charles Schweger is gratefully acknowledged.

cally examined. A modification of the direct centrifugation flotation technique (P. P. Levine, 1939) was used for counting coccidial oocysts in the fecal samples. This modified flotation method produces reasonably accurate quantitative counts of the number of oocysts present. Such oocyst counts provide a yardstick for evaluating the relative abundance of intestinal disease in the population.

All animals shot or live-trapped were sexed and aged. Juveniles were identified by their small size and lack of mammary or testis development. The term juvenile refers to animals less than one year old.

RESULTS

Coccidiosis is a filth-transmitted disease. Its life cycle can be briefly summarized as follows. Sporozoites released from the ingested oocyst penetrate the cells lining the intestine. After a period of asexual intracellular multiplication, an oocyst (zygote stage) is formed from sexual combination of male and female gametes. The oocyst then ruptures the cell in which it has developed and is passed in the fecal stream. Before reinfecting another suitable host, the

TABLE 1. PER CENT CHIPMUNKS INFECTED BY TWO SPECIES OF COCCIDIA DURING SUMMER MONTHS, 1961 AND 1962 COMBINED

Average Date Sampled	Number Examined	Per Cent Infected	
		E. vilasi	*E. wisconsinensis*
		Juveniles	
July 2	31	100	19
August 4	37	97	8
September 4	33	100	24
Total or Average	101	99	17
		Adults	
June 8	25	100	4
July 2	23	100	4
August 4	23	100	4
September 4	17	100	6
Total or Average	88	100	4

TABLE 2. PER CENT RED SQUIRRELS INFECTED BY TWO SPECIES OF COCCIDIA DURING SUMMER MONTHS, 1961 AND 1962 COMBINED

Average Date Sampled	Number Examined	Per Cent Infected	
		E. tamiasciuri	*E. toddi*
		Juveniles	
July 2	18	89	22
August 4	17	100	0
September 4	12	100	17
Total or Average	47	96	13
		Adults	
June 8	5	100	0
July 2	16	100	0
August 4	3	100	0
September 4	10	100	0
Total or Average	34	100	0

oocyst must undergo a developmental process called sporulation, thereby completing the cycle.

In Tables 1 and 2, the incidence of this disease in both hosts in summer is presented. As shown, *Eimeria vilasi* (chipmunk) and *E. tamiasciuri* (red squirrel) are found in almost all animals of both age groups. The two other coccidia, *E. wisconsinensis* (chipmunk) and *E. toddi* (red squirrel) occur infrequently. The absence of juvenile animals in the June sample is due to their small size and infrequent trips away from the nest at this time. In July, when the young are weaned and actively feeding away from the nest, almost 100 per cent of them have become infected with one or more species of coccidia.

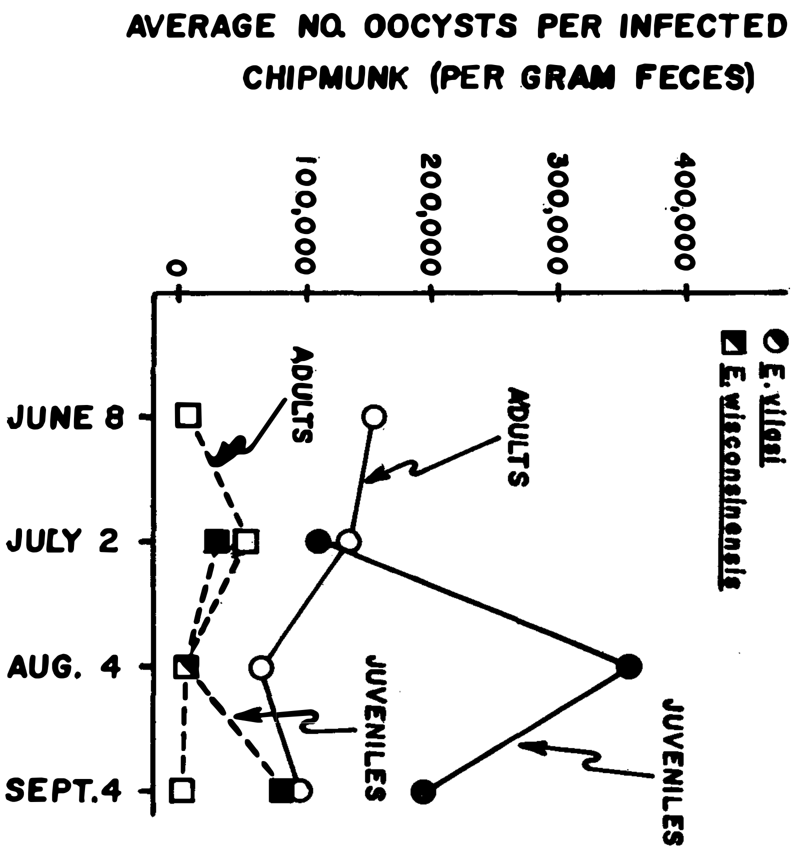

Figure 1. Average number oocysts (per gram of feces) in juvenile and adult chipmunks infected with two species of coccidia, 1961 and 1962 data combined.

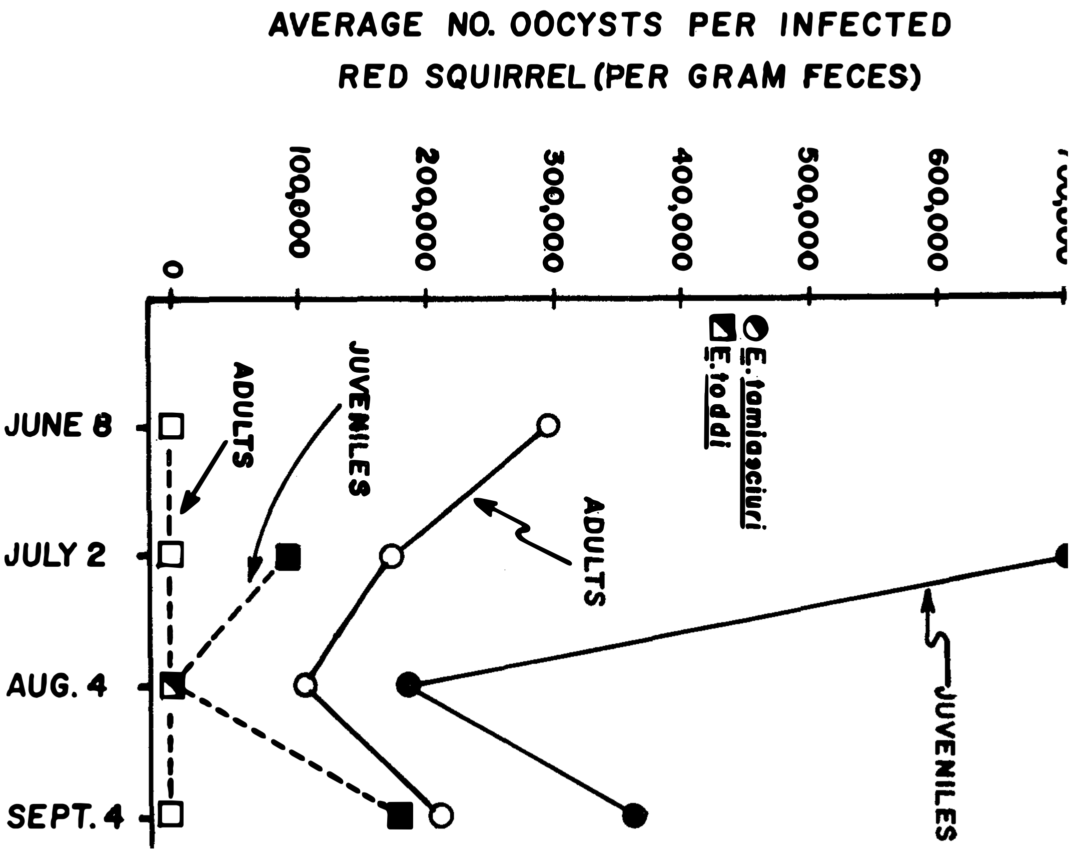

Figure 2. Average number of oocysts (per gram of feces) in juvenile and adult red squirrels infected with two species of coccidia, 1961 and 1962 data combined.

To depict the level of infection in the population of chipmunks, the average number of oocysts (expressed as number per gram of feces) in infected hosts is shown graphically by months (Fig. 1). Juveniles reach a sharp peak of infection with *E. vilasi* in August, contrasted with generally low adult parasitemias. Using the "T" test, the only significant difference in numbers of oocysts between juveniles and adults (Fig. 1) is found in the August sample of chipmunks infected with *E. vilasi* (P. = .05). *E. wisconsinensis* not only has a low incidence of infection in the population (Table 1), but also the average number of oocysts found in infected animals of both age groups is small (Fig. 1).

Data for the red squirrel parallels that of the chipmunk (Fig. 2). *E. tamiasciuri* has both a high rate of infection (Table 2) in the population, and high parasitemias (Fig. 2). *E. toddi,* like *E. wisconsinensis* (chipmunk), has low parasitemias combined with a low infection rate in the population. In general, juvenile squirrels have higher numbers of oocysts than do adults for both species of coccidia. Again using the "T" test, the only significant difference in numbers of oocysts (Fig. 2) between juveniles and adults is found in the July sample with *E. tamiasciuri* (P. = .02).

The comparative morphologies of the sporulated (infective) oocysts of the four species studied (Fig. 3) are based upon drawings from Dorney (1962) and Levine *et al.* (1957). The two species (*E. wisconsinensis* and *E. toddi*) which occur infrequently in their respective hosts, are larger, have a heavy dark outer wall (Dorney, 1962) and have relatively more sporocystic residual material than the two more common species (*E. vilasi* and *E. tamiasciuri*). The sporozoites in these two large species are almost obscured by the sporocystic residual material.

DISCUSSION

Evidence from the first two years of this research indicates that coccidiosis is a common chronic disease in these rodents (Tables 1, 2), as is true in New Zealand and Australia rabbits (Bull, 1958; Mykytowycz, 1962). Doran (1953) found a different situation in Kangaroo rats, with *Eimeria mohavensis* occurring in only 8.7 per cent of 251 *Dipodomys panamintinus mohavensis* examined. Other Southern California rodents which he examined from the genera *Dipodomys, Perognathus, Peromyscus, Onychomys, Neotoma, Citellus, Mus* and *Rattus* were not infected. Since the oocysts of coccidia are known to be killed by desiccation (see e.g. Marquardt *et al.,* 1960), this disease may occur less frequently in semi-arid or desert environments as compared to more temperate areas.

If mortality from coccidiosis occurred, it would probably be in juvenile chipmunks in August when parasitemias (Fig. 1) are at a peak. The proportion of young to adult animals in the sample of trapped and shot chipmunks (Table 1) did not change during the months of July, August and September. Thus indirect evidence of differential juvenile losses is totally lacking. Too few squirrels were trapped or shot to show differential changes in the proportion of juveniles and adults during the summer.

Few outbreaks of coccidiosis causing mortality to wildlife are reported in the literature. Lechleitner (1958) indicated that unnatural flooding of jack rabbit range in California resulted in mortality refer-

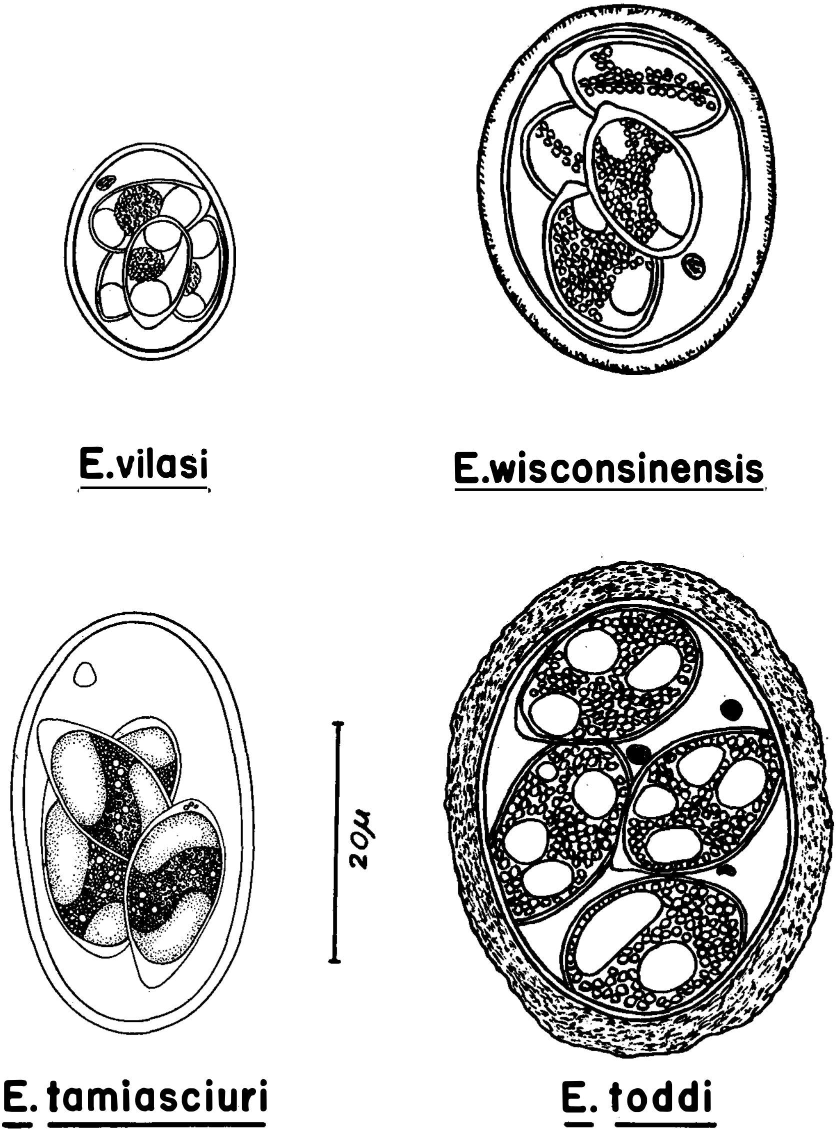

Figure 3. Comparative oocyst morphology (to scale) of the species of *Eimeria* studied in the chipmunk (*E. vilasi, E. wisconsinensis*) and the red squirrel (*E. tamiasciuri, E. toddi*). These drawings reproduced from The Journal of Protozoology by permission of the editor.

able to coccidiosis. He felt that under normal habitat conditions however, coccidiosis was a minor source of loss. Lampio (1951) described an epizootic in Finnish squirrels due to this disease, which "together with the hunting, caused a catastrophic decrease in the population." Farr (1959) reported large numbers of coccidia in the intestines of sick and dying lesser scaup ducks in Michigan. The careful research of Bull (1958) in New Zealand rabbits indicated that *E. stiedae,* a coccidium infecting the liver, apparently caused increased mortality in young rabbits. Mykytowycz (1962) felt that coccidiosis in Australian rabbits was chronic, and of subsidiary importance as a mortality factor.

In this research, coccidiosis in the two Sciuridae studied appears to persist in all age groups with no evidence of mortality specifically related to coccidiosis. However, I do not feel that this apparent lack of mortality means that coccidiosis can be dismissed as a harmless disease in these hosts. The destruction of thousands of intestinal cells by these parasites means that a continual metabolic demand is being placed upon these animals. Since experimental studies indicate that the severity of infection is related to the number of sporulated oocysts ingested (see e.g. Lund, 1949), the high average levels of oocysts (Figs. 1, 2) in these hosts suggest that the potential for a serious epizootic is present in the populations studied. Additional field and laboratory research in wild mammals and waterfowl under varying climatic and population densities is needed to better assess the importance of this protozoan disease.

A definite relationship between the abundance of these four coccidia and oocyst structure and physiology is indicated by this study. The two infrequently occurring species (*E. wisconsinensis* and *E. toddi*) sporulate slowly (2-4 weeks) compared with 2-7 days for *E. vilasi* and *E. tamiasciuri*. This slow sporulation time would retard the effective transmission of these parasites, and is probably a prime factor in the low incidence of these two large coccidia (Table 1, 2).

Since desiccation is a primary factor in the death of the coccidial oocyst (Marquardt *et al.,* 1960), the heavy outer walls of the cysts of these infrequent species would retard water loss, and presumably result in their lengthened survival under natural conditions. Recent morphological studies by Kheissin (1959) indicate that the residual bodies of the oocyst are involved in fat and glycogen storage. As he has shown, these residual bodies (especially the sporocystic residual body) gradually disappear as the sporulated oocyst ages. The large amounts of residual material in the sporocysts of these two infrequent species would also presumably allow for prolonged survival outside the host.

Based on both structure and epizootiology, the coccidia of these two sciurids seem to have become divided into two groups. The *vilasi-tamiasciuri* group is abundant in the hosts, sporulates rapidly and probably has a high environmental mortality due to minimal amounts of sporocystic residual material and a thin cyst wall. *E. wisconsinensis* and *E. toddi* have a completely different host adaptation. Their infrequent occurrence and low numbers in infected animals is apparently compensated for by slow sporulation, abundant sporocystic residual material and a heavy cyst wall.

SUMMARY

Four species of coccidia were studied in the Eastern chipmunk and red squirrel in the summer months, 1961 and 1962. *Eimeria vilasi* and *E. tamiasciuri* were present in almost all animals studied, while *E. wisconsinensis* and *E. toddi* occurred irregularly. The two uncommon species have oocysts structurally adapted for long periods of survival outside the host. In spite of the generally high infection rates, no evidence of direct mortality attributable to coccidiosis was found in these hosts. The occasional epizootics attributable to this disease in wild animals may be related to unusual changes in climatic conditions, or to host density, upsetting what appears to be a very well established host-parasite relationship.

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DISCUSSION

MR. PORSHINSKY [Michigan]: Although you used only fecal examination, do you have any information on *E. stiedae* in squirrels?

DR. DORNEY: We have looked at the gall bladders for oocysts and in this survey of gall bladder material we found nothing. I have not gone through a large number in this manner and we have not done tissue sections of the liver, so I don't know if we have a liver coccidia or not. As far as I know, we do not have one.

MR. PORSHINSKY: The next question I have is on the red squirrel *E. toddi*. The high percentage in the juvenile graduated to nothing in the adult. Would you consider this a form of improvement?

DR. DORNEY: I didn't want to discuss this, because I know so little about it. I hope in the next summer that with experimental infections we can try to determine what is or what is not immunity in hosts. I just can't say. All throughout our incidence studies the adults have fewer coccidia in general, and we did have two significant points of variation between the juvenile and adult infections. In these it may well be that immunity is involved. I think most of the literature which is in this same field which I summarized in my paper would indicate that immunity is involved, but this is only a hypothetical guess at the moment.

THE EXPOSURE OF WILDLIFE WORKERS IN WISCONSIN TO TEN ZOONOTIC DISEASES

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University of Wisconsin,[5] Madison

Individuals pursuing a career in one of the many facets of the wildlife profession experience constant exposure to a variety of wildlife species and environments. Although knowledge of the diseases of wildlife populations is limited, available information indicates that they are exposed to a wide variety of different disease agents (Burgdorfer *et al.*, 1961; Ecklund, C. M., 1960; Jellison *et al.*, 1961; Hanson, 1961; Parker, *et al.* 1961; Karstad *et al.* 1956; McKeever, *et al.* 1958).

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[5]The technical assistance of Anne Zinkhon, Jean Koehler, Sue Sueltmann, David Nassif and Stanley Williams is gratefully appreciated. The cooperation of Chief Warden Walter Zelinski of the Wisconsin Conservation Department is acknowledged.
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To assess the human infection rate of several zoonotic diseases known to be present in wildlife in the Midwest an epidemiologic and serologic surveillance of 155 wildlife workers was conducted by the Department of Preventive Medicine, the State Laboratory of Hygiene, the Department of Veterinary Science of the University of Wisconsin and the Wisconsin Conservation Department.

The limitations of a serological survey were realized, but this approach was considered of value in assessing some of the specific diseases to which the wildlife worker had experienced exposure.

METHODS

Human blood samples and epidemiologic data were collected during the summer of 1962 from 155 professional wildlife workers. All of these workers were Wisconsin Conservation Department employees. Blood samples were obtained in sterile 20 milliliter vacutainers, so that adequate amounts of sera were available for multiple testing. Remaining portions were frozen and stored for possible future testing with other antigens. Epidemiologic data were collected and recorded on marginal punch cards for each individual for future reference and analysis. The information obtained included age, sex, occupations, hobbies, residences, history of contacts with various birds, animals and insects, immunizations, and known or suspected illnesses with zoonotic diseases.

Except for one female biologist, all of the wildlife workers tested in this study were adult males ranging in age from 22 to 64 years (average 39). Of the 155 individuals sampled, 103 were game wardens, 21 game managers, 19 conservation aides and 12 research biologists. At least one serum sample was obtained from those stationed in 63 of the 72 counties in Wisconsin.

Virus tests:

Virus neutralization antibodies to the viruses of eastern, western, St. Louis and California encephalitis, as well as encephalomyocarditis, and the New Jersey and Indiana serotypes of vesicular stomatitis were detected by the colorimetric neutralization test utilizing He-La cell tissue cultures (Kuns, 1962).

The original sources of the virus antigens used in this test included eastern encephalitis virus (AP-218) isolated by Dr. Merle Kuns from a pool of mosquitoes in Georgia, western encephalitis virus (Fleming isolate) from a fatal human case in California, St. Louis encephalitis virus (CDC-904) isolated from a flicker in Kentucky in 1955, encephalomyocarditis virus (CDC-862) isolated from a Florida squirrel by Dr. Robert Kissling, New Jersey serotype of vesicular stomatitis virus (VRL-341) isolated by Dr. Kuns from a cow in Georgia in 1961, and Indiana serotype of vesicular stomatitis virus (laboratory strain) originally isolated from cattle in 1925. The California encephalitis virus (RML 10-8-59) used in this test was originally isolated from a Montana snowshoe hare in 1959 and was supplied by Dr. Leo A. Thomas, Rocky Mountain Laboratory, Hamilton, Montana.

Tests results were recorded as either positive (neutralization) or negative (no neutralization). Neutralization indicated the presence of antibodies or other neutralizing substances.

Bacterial tests:

The sera were examined for evidence of past exposures to tularemia, brucellosis and leptospirosis.

Agglutinins to tularemia and brucellosis were detected by using the rapid plate method with Difco antigens, screening in 1:40 serum dilution and retesting positive sera in additional two-fold dilutions (*Diagnostic Procedures and Reagents,* 1950). A complete agglutination was one giving a 4+ type of reaction, anything reacting less than 4+ was interpreted as partial.

For leptospirosis testing, the live antigen, agglutination-lysis technique was utilized (Galton *et al.* 1962), using ten-fold serial dilutions of sera. Reactions to the antigens in serum dilutions of 1:100 or more were considered as exposures. Ten leptospira serotypes were employed in the survey: *L. canicola, L. icterohaemorrhagiae* A. B., *L.* pomona, *L. hebdomadis* Akiyama C., *L. grippotyphosa, L. ballum, L. autumnalis* A. B., *L. bataviae, L. hyos, and L. australis*).

RESULTS

Viral test results:

The serologic results of the wildlife workers tested for seven virus diseases are categorized by job classification in Table 1. Fifty-three

TABLE 1. NUMBER OF SERA FROM 155 WILDLIFE WORKERS THAT NEUTRALIZED EACH OF SEVEN VIRUSES

Occupational Category	Number Tested	Arthropod-borne Encephalitis Viruses				Other Viruses*		
		Eastern	Western	St. Louis	California**	V.S.-N.J.	V.S.-I.	E.M.C.
Warden	103	0	0	7	33	1	0	2
Game Manager	21	0	0	1	6	0	0	0
Conservation Aide	19	0	0	1	11**	1	0	0
Biologist	12	0	0	0	1**	0	0	0
TOTALS	155	0	0	9	51**	2	0	2

*Others include: Vesicular Stomatitis—New Jersey (V.S.-N.J.), Vesicular Stomatitis—Indiana (V.S.-I.), and Encephalomyocarditis (E.M.C.).
**Sera of ten biologists and one aide were not tested for California encephalitis; therefore, number of neutralizing sera was 51 of 144 tested.

of the sera neutralized only one of the viruses, four sera neutralized two of the viruses, and one serum neutralized three of the viruses.

None of the sera from the 155 persons employed in various aspects of wildlife work neutralized eastern or western encephalitis viruses. Seven game wardens, one game manager and one aide had sera which neutralized St. Louis encephalitis virus. Two sera, one from a warden and one from an aide, neutralized vesicular stomatitis virus of New Jersey serotype, but none neutralized the Indiana serotype. Sera from two game wardens neutralized encephalomyocarditis virus. Fifty-one of 144 sera tested (35%) neutralized California encephalitis virus.

Because of the large number of sera neutralizing California encephalitis virus (CEV) these results received additional consideration. The geographic distribution of wildlife workers in Wisconsin whose sera neutralized CEV is illustrated in Figure 1. Although those sampled constituted a non-random distribution and many of the individuals were stationed in different parts of the state, the percenage of neutralizing sera from those living in the central part of the state (Juneau, Jackson and Wood counties) appeared quite high. Adequate numbers of sera have not been examined for final comparisons.

Comparisons were made of the relative numbers of sera neutralizing CEV from those in the various job categories. There were 33 positive sera from 103 wardens (32%), 6 from 21 game managers (29%), 1 from 2 biologists and 11 from 18 aides (61%).

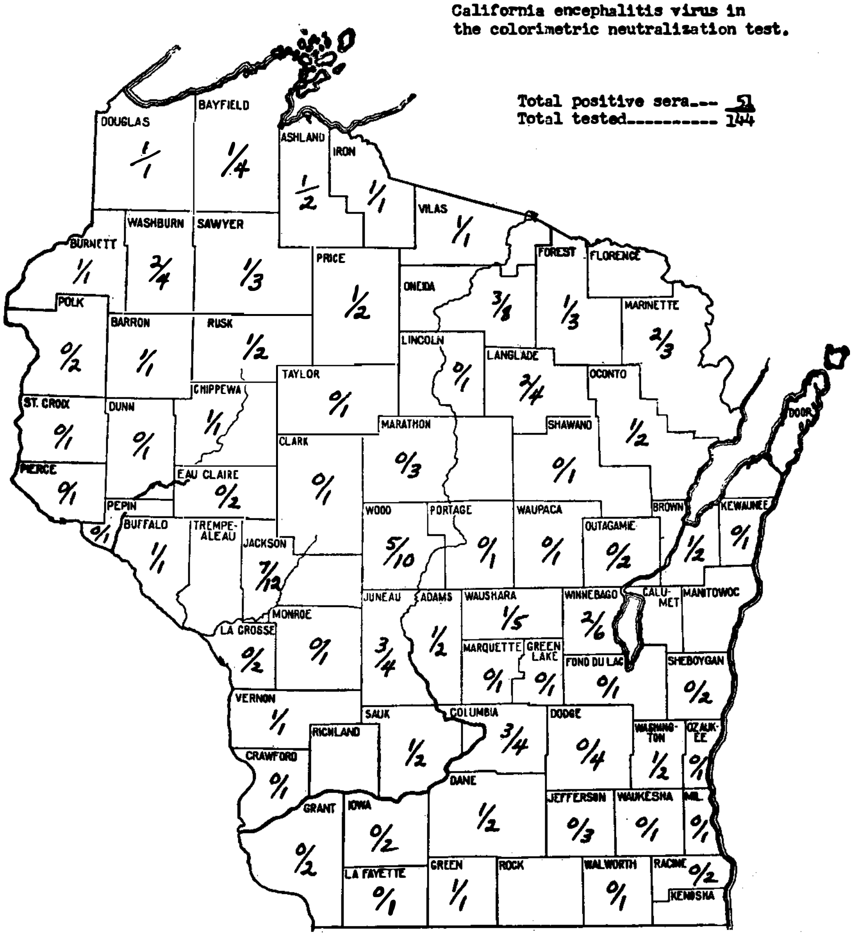
The percentage of workers with positive sera was higher in the older age groups with 16% of those under 34 years of age, 41% of those 35-44, 49% of those 45-54, and 83% of those 55 years of age and older.

There was also a greater percentage of wildlife workers with sera neutralizing CEV in those working the longest in each of these job categories. The wardens with neutralizing sera had an average of 19.9 years service in the Conservation Department, while those with negative sera had an average of 13.4 years. Game managers with neutralizing sera had an average of 23 years service, while those with negative sera had 12.7 years. Conservation aides with positive sera had been in the Department for an average of 12.9 years, while those with negative sera had only 2.9 years service on the average.

To further confirm the California encephalitis test results, five sera which had been screened in the colorimetric neutralization test were tested with the same virus in mouse neutralization tests. Three sera neutralizing the virus in the colorimetric test neutralized 2.6, 3.0 and 3.3 logs LD_{50} of virus in mice, while two sera from the group which

Figure 1.

Distribution of wildlife workers whose sera inhibited California encephalitis virus in the colorimetric neutralization test.



The number of positive sera per county is listed (numerator) over the total number tested (denominator).

were negative in the colorimetric neutralization test showed no neutralization of the virus in the mouse neutralization tests.

Bacterial test results:

When screened with tularemia antigen three sera diluted 1:40 showed complete agglutination. One of these, from a warden, showed highest agglutination at a dilution of 1:160, while the other two, from a warden and a biologist, showed agglutination in the 1:40 dilution. Thirteen other sera, diluted 1:40, showed only partial agglutination: eleven of these also partially agglutinated brucella antigen in the same dilution, indicating the presence of nonspecific agglutinins in these low dilutions. None of the sera, diluted 1:40, produced a complete agglutination with the brucella antigen.

One conservation aide reported a history of hospitilization due to illness the week prior to sampling. His illness was characterized by a severe infection in the little finger of his right hand, swollen and inflamed lymph nodes and high fever and chills which responded to treatment with antibiotics. His serum, collected one week after the onset of his illness, showed partial agglutination at a dilution of 1:40 with the antigen for tularemia. Because of his history of an illness resembling tularemia a second sample was obtained 27 days after the onset and this serum agglutinated tularemia antigen when diluted 1:320. Several other workers with partial agglutinations reported histories of suspected tularemia infections in past years.

In the agglutination-lysis test for leptospirosis only one serum reacted in 1:100 dilution with the antigens. This serum, from a game warden, reacted with both *L. canicola* and *L. grippotyphosa.*

Medical histories:

There was no report of recognized illnesses with any of the diseases considered in this survey, except tularemia. There was no report of immunization for any of these diseases.

DISCUSSION

Eastern and western encephalitis virus:

The serologic results of the 155 wildlife workers (Table 1) showed no evidence of recent exposure of individuals in this group to either eastern encephalitis virus (EEV) or western encephalitis virus (WEV). On the basis of the prevalence of antibodies and presence of virus, EEV has been widespread throughout Wisconsin in a variety of wildlife species (Karstad *et al.,* 1960, Trainer, 1961). Approximately half of 200 pheasants and ruffed grouse examined since 1956 had EEV neutralizing sera and the virus has been isolated from a wild pheasant in the state. Many of the wildlife workers sampled in this study had direct and/or indirect contact with both pheasants and ruffed grouse, yet none of the human sera neutralized the virus. Although information on the status of WEV among wildlife species in the state is not as extensive as that of EEV, it has also been present.

From these results it is evident that although a disease was prevalent among certain wildlife species, its methods of transmission may be such as to limit its introduction into other species which associated closely with it. There is no evidence in this study that the arthropod vectors of EEV and WEV among the wild species involved in Wisconsin have transferred this virus to the wildlife workers.

St. Louis encephalitis virus:

Nine of 155 sera neutralized St. Louis encephalitis virus (S.L.E.) in the colorimetric neutralization test, indicating some previous contact of these individuals with this or a closely related group B arthropod-borne virus. There was no apparent difference in the exposure rate of the various job categories to this agent. The significance of these serologic results is unknown at the present time. Further investigations of the specificity of the serologic reactions and the isolation of the virus are needed before an evaluation of SLE activitity in Wisconsin can be made.

California encephalitis virus:

On the basis of serologic results, exposure of wildlife workers in Wisconsin to California encephalitis virus or a closely related virus was high, with 35% of the sera from the individuals neutralizing the virus. This constituted the largest percentage of neutralizing sera observed in this study. To our knowledge this is the first serologic evidence of human infection with CEV or a closely related virus in Wisconsin.

California encephalitis virus was originally isolated from ***Culex tarsalis*** and *Aedes dorsalis* in California (Hammon & Reeves, 1952). Serologic evidence associated the virus with three cases of encephalitis in an infant, a child and a young adult. A serologic survey showed about 11% of the human inhabitants of the area to have antibodies. There was no isolation of the virus from a human case.

The only known isolate of CEV from a naturally infected vertebrate was made from a snowshoe hare (*Lepus americanus*) in Montana (Burgdorfer *et al.*, 1961). Serologic studies in Montana indicated high exposure rates among horses, cows, hares, rabbits, and ground squirrels. As a result of these studies in animals the known geographic distribution of the virus has rapidly expanded from California, and wider distribution than was previously assumed is apparent. In Wisconsin, neutralizing sera have also been detected in sera of snowshoe hare and deer (Trainer, 1963).

The public health importance of CEV infections is not known. The lack of recognized illness among the large number of persons with neutralizing sera in this study further indicates that the virus usually produces mild or subclinical infections in man.

The relatively high percentage (61.1%) of CEV neutralizing sera from conservation aides suggests a high rate of exposure from this group. The conservation aides carry on much of the manual outdoor labor for the Conservation Department, providing them with excellent opportunity for exposure to arthropod vectors.

The geographic distribution of wildlife workers in Wisconsin having sera neutralizing CEF (Figure 1) appears centered in the west central part of the state. The geographic distribution of deer having neutralizing sera for CEV presents a similar geographic pattern (Trainer, 1963).

An increase in the percentage of CEV neutralizing sera in those employed the longest suggests that virus activity has been present for a number of years and that these individuals have had greater chance for exposure; however the serologic results of the deer samples indicate recent virus activity in the state since the majority of the deer were less than three years of age.

The geographic distribution, age distribution and relatively large per cent of reactors among a small group of workers points the way for more concentrated studies in these groups and areas. This illustrates the important role that serologic studies can play in initiating epidemiologic investigations.

Encephalomyocarditis:

Less than 2% of the 155 wildlife workers' serums tested neutralized encephalomyocarditis (EMC) virus. The results appear similar to those reported in other studies where about 3% of the population in their study were found to have antibodies (Jungeblut, 1950).

Vesicular stomatitis:

Sera from two of the individuals tested, one game warden and one conservation aide, neutralized virus of the New Jersey strain of vesicular stomatititis (VS-NJ). An epizootic of VS-NJ occurred in Wisconsin during 1949 (Brandly, 1951). There has been no report of natural infection of either man or animals in Wisconsin since then. These two men were both in or close to the area of the epizootic in 1949 and could have developed antibodies to this virus by contracting the infection during the outbreak in animals. The possibility of these individuals visiting other areas of the country where the disease is still endemic also exists.

None of the sera neutralized the Indiana strain of Vesicular Stomatitis. There has been no evidence of its activity in Wisconsin. Additional tests are in progress to learn more about the sensitivity and specificity of the tests. Sera from other groups of the population are being tested for comparisons. Virus isolation attempts are being made.

Tularemia:

Three sera producing agglutinations of tularemia antigen, along with an associated clinical case, indicates that these workers have contracted tularemia infections.

Tularemia has occurred in both muskrat and beaver in Wisconsin, and the causative organism, *P. tularensis,* has been isolated from one or both of these wildlife species regularly (Trainer, 1958).

Many of these wildlife workers have had close contact with both beaver and muskrat. For example, one biologist's major research has been a field study of muskrat populations. Some of the conservation wardens located in optimum beaver range handle and tag as many as 200 beaver a year. The possibility of exposure to tularemia exists and is quite great in this group.

Brucellosis:

There was no evidence to indicate that brucellosis was a disease problem in this group.

Leptospirosis:

Leptospira pomona is enzootic in Wisconsin deer (Trainer, *et al.,* 1963). Many wildlife workers in the state, especially wardens, have direct contact with and handle hundreds of deer annually. This includes field dressing car-killed and shot animals, yet none of these individuals had sera which reacted with *L. pomona* or any of the other serotypes present in deer. The importance of the mode of transmission and of basic research into the natural history of disease is evident.

SUMMARY

An epidemiologic and serological study was made in Wisconsin to determine the risks of exposure of wildlife workers to certain zoonotic diseases found in the wild animal populations with which they have relatively close contact.

Epidemiological data and blood samples were collected from 155 Wisconsin Conservation Department workers during 1962. None of the sera neutralized eastern or western encephalitis viruses. Nine sera neutralized St. Louis encephalitis virus, two encephalomyocarditis virus and two vesicular stomatitis virus. Fifty-one of 144 sera neutralized California encephalitis virus. There was lack of histories of encephalitis or related illnesses in these individuals.

There was serologic and clinical evidence of tularemia indicating human infection has occurred. No positive evidence of brucellosis was found in this group. Only one serum reacted with leptospira antigens.

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DISCUSSION

DR. JOHN DEBBIE [Ontario Vet. College]: Dr. Thompson, I was wondering whether you planned to do any control of sera from people who are not wildlife workers or veterinarians.

DR. THOMPSON: Yes. We are at the present time testing children's sera. We have a group of a hundred samples from children, and we are testing sera from each age, from three to nineteen. We also will have sera available to us from medical examinations and so forth that we can test, and these are some of the controls that we will use before these results can be final.

PROFESSOR DAVIS: I just want to check on one item, Dr. Thompson. If I have the data correct, out of the 144 sera tested or neutralized in that group you had 55 that did react and there were no local cases that were reported at all; is that right?

DR. THOMPSON: Yes, although 35 per cent of these sera neutralized the California encephalitis virus, none of the workers reported an associated clinical case of encephalitis. It might be possible that some of these are just mild headaches or very mild cases that did not cause much damage. It may be possible in some cases that infections occurred and were not recognized, or that they were not diagnosed. It's also very possible that the disease may be more serious in children because it was associated in three cases in California, with children and young adults.

DR. KARSTAD: You mentioned that you were testing other groups. I believe you mentioned a group of veterinarians and you're interested in additional groups. Can you make any general statement at this time as to how—even though the surveys may not be complete, as to how the serological reactors compare in other occupational groups with what you got in the wildlife people?

DR. THOMPSON: Our data on those are not complete as yet. We are just now starting to test the sera from the veterinarians that we collected at the state meeting in Milwaukee, but we would guess, according to preliminary results, that some twenty per cent of those will be positive with the California encephalitis virus. This would indicate that perhaps a fifth of the veterinarians are exposed, and it will be interesting to see what their geographic distribution is, to see if it compares with that of the wildlife workers, and to see what the age distribution is, too. Of course, we would like to isolate the virus, but the virus, as far as I know, has never been isolated from a human case, although it has been isolated from a snowshoe hare in Montana.

A CRITIQUE ON THE TROPICAL CATTLE FEVER TICK CONTROVERSY AND ITS RELATIONSHIP TO WHITE-TAILED DEER[1]

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During the latter part of the nineteenth century, a mysterious malady was imposing staggering financial losses upon cattlemen of the Midwest. These were estimated at $40,000,000 annually, and the dread disease precipitated great strife and hardship for many cattle barons of the post-Civil War frontier. This insidious sickness became particularly conspicuous when Texas cattle were driven to the great railheads of Kansas City, Dodge City, Abilene and Wichita. Trails

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of death subsequently were left for countless thousands of northern cattle, and the entity became known as, "Texas Cattle Fever."

Paquin, in 1887, was one of the first to record pertinent, epidemiologic factors related to the condition. This investigator noted that previously contaminated pens, barns, and pastures were dangerous during the warmer months, but from the first heavy autumn frost through the last severe spring frost, "Texas Cattle Fever" was conspicuously rare. It was six years later, in 1893, that Smith and Kilborne reported their epoch-making findings which incriminated a protozoan (*Babesia bigemina*) and an arthropod (*Boophilus annulatus*) as concomitant factors in causing this costly disease. It therefore was established that at least one species of tick (*B. annulatus*) was essential in order for the microscopic blood pathogen to be transmitted between mammalian hosts. This was the first authentic account of an arthropod as an intermediate host of a protozoan parasite.

Since this landmark in medical research, "Texas Cattle Fever" acquired many synonyms. These included: Texas fever, cattle fever, tick fever, red water fever, bovine malaria, piroplasmosis, and babesiasis.

Two important facts were disclosed which led to total tick eradication. First, the tick is a one-host tick, completing its life cycle on one animal. Second, cattle are the only animals which contract the disease caused by *B. bigemina.*

After the etiology of babesiasis had been determined and the life cycle of *B. bigemina* was delineated, 13 years of additional research were essential before a nationwide, fever tick (*B. annulatus*), eradication program was feasible. According to Williamson (1951), two functional eradication programs were developed in Louisiana. This account cited that Dr. H. A. Morgan, entomologist, designed a pasture rotation system of management whereby ticks were exterminated through starvation. A second procedure was perfected by a chemist, Malcom S. Dougherty, which consisted of dipping livestock in a weak arsenical solution.

Dipping was elected as the most feasible method for a national cattle fever tick eradication program, and in 1906 the mammoth project was inaugurated. Throughout every fever tick-infested area, concerted efforts were made to dip all cattle, horses, and mules every two weeks in a 0.19 per cent arsenical solution. This costly undertaking was highly successful, and by 1943 all of the United States, except a buffer zone along the Rio Grande of Texas and restricted localities in Florida, had been declared free of *B. annulatus* (USDA Rpt., 1962).

These refractory sites remained in spite of intensified eradication efforts. The reason in Texas was quite obvious, as tick-infested cattle from Mexico were perpetually drifting across the shallow Rio Grande into adjacent Texas counties. Florida presented an entirely different situation. Many workers claimed deer were responsible for the propagation and perpetuation of fever ticks, and others indicated that feral cattle were reservoirs. Some investigators were convinced that all cattle, horses, and mules were not dipped in compliance with United States Department of Agriculture regulations.

Although cattle fever-tick eradication was initiated in Florida in 1913, an accelerated program was not commenced until 1923 (MacKellar, 1941). This work started in northwestern Florida and progressed eastwardly to the Atlantic Coast. The results were very encouraging until 1931, when "breaks" occurred in Orange County. In Congressional Hearings before the 77th Congress Applewhite (1941a) reported that the eastern section of Orange County had been released from quarantine, but within a few months it was declared reinfested. Dipping procedures were repeated, and during this time ***B. microplus,*** the tropical counterpart of ***B. annulatus,*** was identified from white-tailed deer (*Odocoileus virginianus*) obtained within three large game preserves of Orange County. These findings offered convincing proof that wild deer were harboring the tropical variety of fever ticks (***B. microplus***), but conclusive data still were not available on the ability of these arthropods for perpetuating their species on white-tailed deer (*O. virginianus*). In view of the crisis that had been precipitated, circumstantial evidence favored the former concept.

A storm of controversy was exhibited by many persons concerned with the tick eradication program in Florida. For instance, in a letter to Henry A. Wallace, Secretary of Agriculture, John Collier, Commissioner of Indian Affairs, wrote: "Dr. Knapp, of the Florida Livestock Sanitary Board, states that the cattle is the preferred host, and that is his explanation why allegedly the tick can be eradicated without the eradication of deer in those areas of Florida where deer and cattle browse together. Dr. Knapp explains that there is a constant migration of the tick from the less preferred deer to the more preferred cattle, and as the cattle are dipped, ultimately all of the ticks get caught. But Dr. Mohler, of the Bureau of Animal Industry, states as a fact the opposite of that which Dr. Knapp states. Dr. Mohler states that the deer is the preferred host. Hence the migration would be from cattle to deer, not vice verse, and the dipping of cattle would not, by Dr. Mohler's theory, explain the alleged eradication of ticks in those areas where cattle and deer browse together" (Collier, 1941).

When officials of the Bureau of Animal Industry (USDA) became convinced that deer (*O. virginianus*) were reservoir hosts for tropical fever ticks (*B. microplus*), consultation was obtained with the Bureau of Entomology and Plant Quarantine. After visiting and studying the area, personnel from the latter organization shared the same opinion, and in 1937 legislation was passed for a drastic reduction in deer populations of Orange and Osceola Counties (Applewhite, 1941b).

Of 715 deer shot and examined in Orange and Osceola Counties, 122 were infested with *B. microplus*. The last "ticky deer" from this area was reported in March, 1939, but the annihilation of these animals continued through December, 1939, (Applewhite, 1941a).

It is of significance that while deer were being liquidated, an intensified cattle-dipping program was being conducted in the same area. Fever ticks (*B. microplus*) were not found on cattle during this interval, or throughout examinations that continued for two additional years. The deer slaughter program expanded into Highlands, Glades, Polk, Okeechobee, Charlotte, and Hernando Counties of Florida, and thousands of deer were killed.

Persons opposing the deer slaughter program contended that vast areas within the southeastern United States, which abounded with deer, had been freed of fever ticks (*Boophilus* spp.) without a reduction of deer herds. Conner (1960) stated that while working with the tick eradication program in Louisiana and Mississippi, engorged female fever ticks were not found on deer, although most cattle were heavily infested before dipping was inaugurated. Success of the overall program was attributed to strict adherence of regulations, whereas all age groups of horses, mules, and cattle were dipped every 14 days. When Tick Eradication Supervisor, Dr. Dudley D. Conner, was questioned on how old a calf should be before dipping, his reply was, "If it's born it's old enough to dip."

This rigid concept was followed throughout the native deer country of Louisiana and Mississippi, and it was not necessary to rework any area which once had been declared tick free. Deer were not killed anywhere in these states during the fever tick eradication program, yet the undertaking was highly successful.

When the eradication program reached southern Florida, tick infested deer again were encountered, and because of the apparent success of the deer reduction program in Orange County, legislation was approved for deer slaughter in Collier and Hendry Counties. Permission was requested from the Indian Service to shoot deer on the Seminole Indian Reservation adjacent to these counties, but the request was denied because sound scientific investigations had not been conducted to determine if deer actually were prepetuators of tropical fever ticks (*B. microplus*). Many persons accused the Indian Service of being a "stumbling block" in the tick eradication program of Collier and Hendry Counties.

It was suggested that an unbiased third party investigate the possibility of tick eradication without the necessity of killing deer on the reservation. The Department of the Interior therefore requested the Audubon Society to initiate a tick survey. After visiting the reservation to determine if a study was indicated and feasible, Herbert L. Stoddard, Director of the Cooperative Quail Study Association, Thomasville, Georgia, accepted directorship of the program. His appointment was agreeable to all parties concerned (Stoddard, 1960).

One of Stoddard's assistants, Roy Komarek, established residence on the reservation in May 1941, and for the following two years deer and other native animals were examined for *B. microplus*. During this period, an initial stock of 150 tick-free native cattle were introduced into fenced enclosures within the Indian Reservation. This phase of study was under strict supervision by the Audubon Society investigators, with an ultimate goal of determining whether or not cattle fever ticks still were on the reservation. An intricate part of the study involved repeated driving of cattle through habitat frequented by deer, thus affording "magnets" to attract ticks. After two years of examining deer, cattle, raccoons, rabbits, squirrels, and birds, not one cattle-fever tick was found on the entire reservation (Komarek, 1960).

In the spring of 1943, Komarek left the reservation but for an additional two years animals were reinspected at monthly intervals. Cattle fever ticks were not found on the Indian Reservation at any time during the program, and in 1943 the quarantine was lifted without the necessity of killing deer. Southern Florida therefore was declared essentially free of cattle fever ticks.

Boophilus microplus was not reported again in Florida until the winter of 1945, when reinfestation occurred in Okeechobee County. During 1947, these ticks appeared in Palm Beach, Broward, Charlotte, Collier, Dade, Hendry, and Lee Counties. In 1948, *B. microplus* was reported in Volusia, Putnam, Flagler, Brevard, Osceola, Lake, St. Johns, Alachua, Orange, Madison, and Jackson Counties in Florida, and one area in Brantley County, Georgia. Federal quarantines subsequently were established, but systematic inspection and dipping domestic animals brought these tick outbreaks under control. This quarantine was removed in December 1950, and the Florida tick eradication program was considered complete.

Another tick outbreak occurred during the summer of 1957, in

Okeechobee, Broward, Highlands, Dade, and Palm Beach Counties, Florida, but eradication was pronounced successful in September 1958. The next evidence of *B. microplus* in Florida was in May 1960, at the Okeechobee Livestock Market. A State Tick Quarantine line, which passed through Ocala, Florida, was established and regulations required inspection and dipping of animals moved north of this line. Livestock was routinely dipped in areas of infestation and the campaign was pronounced successful in October 1961 (USDA Rpt., 1962).

The source of these tick reoccurrences remains a mystery, but some persons suspect deer as reservoirs of these arthropods. A contrasting opinion was illustrated by correspondence from Dr. C. L. Campbell, Florida State Veterinarian, to Louis E. Burnett, Deer Study Leader, Louisiana Wild Life and Fisheries Commission. Dr. Campbell stated, "It may be of interest to you to know that there have been 3 spotted reinfestations of cattle fever ticks in Florida since 1944, however, deer were not a factor in either of these 3 programs." (Burnett, 1961).

To secure additional information relative to the possibility of deer being infested with cattle-fever ticks, Florida Game and Fresh Water Fish Commission Biologists examined several hundred wild deer killed during 1960 hunts. Although *B. microplus* was not found in this study, valid conclusions could not be made.

Deer herds in the Southeast are expanding at a tremendous rate. Game and Fish Agencies are stocking and protecting this big game species in many areas that have not supported deer since the turn of the century. For this reason, deer probably are more numerous now than at any time since white man first came to this continent. As numbers of deer increase, the probability of tick infestation also is augmented, and procurement of information on the preferred host becomes more imperative.

Increasing deer herds constitute anxiety for cattle producers. This apprehensiveness is due to the white-tailed deer's ability to move unrestrained from one pasture to another, and cattle-fever ticks could be transferred in this manner. It therefore is likely that if *B. microplus* were accidently introduced into the southeastern United States and subsequently found on deer, great controversy would ensue and cattlemen/sportsmen relationships would be drastically affected. This would result because the host/parasite relationship has not been determined through basic scientific research.

Livestock on many Caribbean Islands are heavily infested with tropical cattle-fever ticks, and the danger of reintroducing these arthropods onto the continental United States is imminent. For example, a visiting cattleman could leave a contaminated pasture or corral with hundreds of seed ticks attached to the clothing. With jet airliners making daily trips from these islands, it probably is only a matter of time before *B. microplus* will reappear in the Southeast. In the event that *B. microplus* is reintroduced into Florida or Texas, it is likely that the parasites will be disclosed by vigilant tick inspectors before they become well established. On the other hand, if these ticks are transplanted to other areas of the Southeast, they could very possibly become widespread before identification has been accomplished.

In view of the increasing hazards relative to an introduction of *B. microplus,* time is of the essence for initiating a research program designated for procuring basic information on the host/parasite relationship of these arthropods. St. Croix, United States Virgin Islands, offers what may be a last opportunity to conduct this highly desirable tick/host study. This island is the only remaining United States possession where *B. microplus*-infested deer and cattle are available, and it subsequently constitutes an ideal study area.

Cattlemen of St. Croix are not nearly as concerned with the presence of *B. microplus* as would be the case on the continent. Cattle of this island are relatively immune to piroplasmosis, therefore, the disease does not present a major problem. At present, St. Croix livestock producers probably would not be enthusiastic for a fever tick eradication program, unless it encompassed slaughtering all deer concurrent with dipping livestock. The latter approach, however, would eliminate this unique opportunity for investigating a host/parasite relationship, from which urgently needed basic information can be readily obtained.

An initial study should be conducted with penned deer and cattle. A deer-proof enclosure of 20 acres is suggested, whereas tick-infested animals can be pastured together. In a compound of this type, cattle could be examined and dipped at two-week intervals, with the deer remaining undisturbed. If it is found that fever ticks can be eradicated from this experimental environment, without the necessity of exterminating deer, data thusly gained can be of insurmountable value to the livestock industry and deer management. On the other hand, if deer are found to be capable hosts for *B. microplus,* and these parasites can successfully negotiate repeated life cycles without utilizing cattle hosts, this information also will be of paramount significance for future tick control programs.

For the duration of the pilot study, it is suggested that all natural potentials of St. Croix be preserved for a possible, future, large-scale, research program that might utilize information procured from the initial investigation. It therefore appears that during this interval, the St. Croix deer herd should be retained or even allowed to increase.

If preliminary findings should indicate that dipping cattle alone will eradicate *B. microplus*, then the entire island might later be considered as a larger study area for duplication of the limited investigation. In the event that penned experimentations are questioned, these potentials shall have been conserved for future endeavors.

Data acquired from this proposed protocol could be a tremendous asset to future cattlemen/sportsmen relationships. Then, if *B. microplus* is introduced in the southeastern United States, both the livestock industry and wildlife profession would be in position to make an immediate decision relative to whether or not deer liquidation is necessary.

A research program of this type should be of paramount interest to the Virgin Islands Government, the United States Department of Agriculture, Official Wildlife Agencies, and all individuals involved in livestock production or interested in conservation of natural resources. If this opportunity is wasted, modern rapid transportation inevitably will precipitate a situation to be regretted by many livestock producers, sportsmen, and millions of other taxpaying Americans.

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PARASITES AND DISEASES OF BISON IN CANADA II. ANTHRAX EPIZOOTY IN THE NORTHWEST TERRITORIES

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The bulk of the bison population in Canada is found in Wood Buffalo Park, a 17,300-square-mile area which straddles the Alberta-Northwest Territories border. At present there are about 10,000-12,000 bison in the area. In addition, some 3,000 bison roam outside the park limits, north of the 60th parallel of latitude in the Northwest Territories.

On July 28, 1962 one of the authors (G.B.K.), while on a range-sampling flight (helicopter), observed 32 dead bison in 2 meadows on the east side of the Slave River, north of Hook Lake (Fig. 1). The area is some 60 miles north of Fort Smith, Northwest Territories, and about 15 miles from the northeast boundary of Wood Buffalo Park. More dead animals were located in the following 24 days. Laboratory examination of the animals showed the cause of death to be anthrax.

Altogether, 281 bison were found dead in a 700-square-mile area (60°-35′—61° N by 112°-15′—113°-15′ W) around Hook Lake, between the Slave River in the west and the Talston River in the east. The over-all sex ratio of the dead animals was 59 males to 41 females, and the great majority of the cadavers were those of mature animals. At some places in the area, the ratio of dead animals was 80 males to 20 females. Eight animals exhibiting signs of illness were shot for examination.

It is reckoned there were approximately 1,300 bison in the area where the dead animals were found. The remainder of the 3,000 bison outside the preserve limits were then on the west side of the Slave River, in the Grand Detour area. In the summer months the animals on the east side of the Slave River are isolated from the park and there is little interchange of animals. However, this is not the case in the winter when the animals can cross the river on the ice.

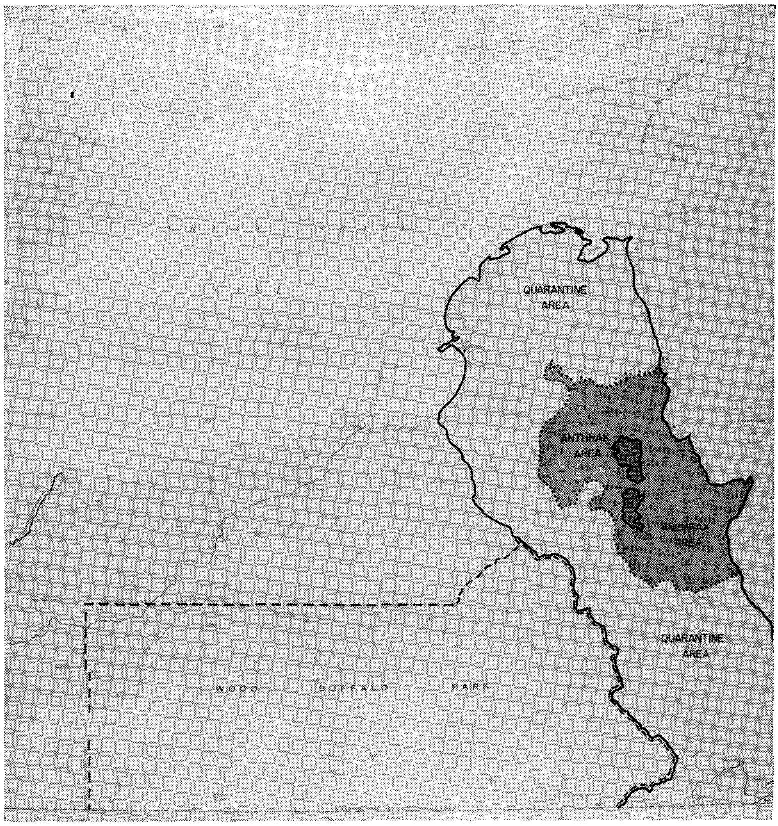

Figure 1. Anthrax outbreak in bison in the Canadian Northwest Territories, July-August 1962. The darker regions within the anthrax area indicate the two locations where the greatest number of dead bison was found.

SYMPTOMS, LESIONS AND DIAGNOSIS

During the outbreak it was possible to observe animals exhibiting signs of illness. The animals, head lowered, gaunt and drawn, feeding voraciously at times, were depressed and inordinately indifferent, whereas they should have been active and alert, as the outbreak occurred during the rut period. Most of the animals walked with difficulty, staggered at times, and exhibited a stiff-legged gait when running. Also, a swelling of the preputial and umbilical region was noted in many animals. Cadavers were bloated and dark blood exuded from the body openings.

Oedematous swellings were noted in the eight animals that were shot. In six animals the swelling was in the renal region, extending into the pelvis; in male animals the preputial region was swollen also. In one animal, the swelling, measuring approximately 6″ by 6″ by 10″, was confined to the pharyngeal region, and in another to the shoulder.

There were petechiae on the spleen of five of these animals. The borders of the spleen were rounded, but in all cases the spleen was not enlarged and its consistency was normal. In seven of the animals that were thus examined, the lymph nodes in the region of swellings were hypertrophied and slightly haemorrhagic. In all cases the intestinal tract was congested, but the consistency of the faeces was normal. The rumen contained a normal amount of food. In two of the animals it also contained a quantity of fluid estimated at one gallon. Other viscera, such as the liver, the pancreas, the kidneys, and the urinary bladder, were congested. In all cases, the blood clotted in what was considered normal time. However, it is well to remember that the above lesions were noted in animals in which the disease had not run its natural course.

On August 15, an autopsy was also performed by Dr. A. E. Lewis of the Canada Department of Agriculture and one of the authors (N.S.N.) on an animal that had died the night before. Oedematous swellings and a bloody discharge from the body openings were noted. There was some degree of rigor mortis in the bloated animal. The spleen was about twice its normal size and haemorrhagic, and other viscera were congested. The blood was dark and failed to clot.

Bacillus anthracis was isolated through guinea-pig inoculation of oedematous subcutaneous tissue, liver, spleen, and lymph nodes from seven of the eight animals that were shot and examined between July 28 and August 7.

PROPHYLACTIC MEASURES

In accordance with "The Animal Contageous Diseases Act" of Canada, the outbreak was reported to the Health of Animals Division of the Department of Agriculture as soon as the nature of the disease was established, and steps were taken for the proper disposal of the dead animals by liming and burying and, in some cases, by burning. Field parties for this purpose operated under the supervision of federal veterinarian Dr. William Norton. A sizeable area east and west of the Slave River was quarantined under the authority of the Act, prohibiting the movement of bison products out of the area. Steps were taken also to ensure the safety of personnel engaged in this operation and the decontamination of clothing and equipment at its completion. The local population was alerted also as to the danger of contact with sick or dead animals.

Other prophylactic measures included the herding of the animals still in the contaminated area to its periphery from whence they were dispersed north and south of the danger zone after a 10-day holding period. The animals were moved because it was deemed advisable to burn off the 700-square-mile outbreak area to discourage animals from returning to it. Inclement weather did not permit the burning of more than 15 per cent of the area. This operation was under the supervision of the Northern Administration of the Department of Northern Affairs and National Resources. By November, air observations indicated that a large number of bison had returned to the area from which they had been driven off earlier.

DISCUSSION

There have been numerous reports of anthrax in livestock in North America, where the disease has been known to exist since the early 1700's. It is believed that it was prevalent in deer in Louisiana at the time of its settlement by the French (Stein, 1945). In recent years it has been reported in deer in Florida, Louisiana, California, and Texas (Stein and Stoner, 1952; Stein and an Ness, 1954; Stein, 1954), as well as in moose in Wyoming (Good, 1956).

It is believed that the disease occurred in bison on the western plains (Stein, 1948). Soil contamination persisting to this date would account for outbreaks in livestock in some areas. However, there are just a few reports of anthrax in bison in North America, two of which refer to its occurrence in bison in captivity (Halloran O'Connor, 1955). It is supposed that newly introduced bison from the Middle West were at the origin of the outbreak in the Highland Park Zoological Garden, Pittsburgh, Pennsylvania, in 1947 (McNary, 1948). A few years ago, the disease was reported (Public Health Service, 1956) in two men in New Mexico following the butchering of a sick buffalo from a herd where four animals had died. *Bacillus anthracis* had been recovered from one of the animals.

The present outbreak is the first instance of the disease being recognized in bison, or for that matter in any wildlife species, in Canada. There is no indication as to how and when the disease was introduced into the Northwest Territories. However, in connection with this outbreak, it should be mentioned that during the winter of 1960-61, 25 horses died that had been brought from Alberta into the Hook Lake area and the neighbouring Hay Camp area. In no case was the cause of death established nor an attempt made then to establish it. Whether there is any relationship between the horses' death and the outbreak is not known. Laboratory examination of a long bone and hide from one horse in each locality by Dr. G. R. Whenham of the

Alberta Department of Agriculture in the autumn of 1962 failed to reveal any clues as to the cause of death.

Field observations indicate that the disease occurred in an acute and rapidly fatal form, as well as in a less acute form, as evidenced by the recovery of a number of animals, as sometimes occurs in cattle, horses, and sheep. As stated previously, dead animals were first noted on July 28, and from that date a close watch was kept on the entire area. Judging from the state of the first cadavers that were found, death occurred only a few days before July 28. Between July 28 and August 4, some 120 dead bison were spotted. This was followed by a 10-day period during which, as far as it was possible to ascertain, there were no more deaths. However, between August 15 and August 21, some 160 bison died. Animals which were found dead after the 10-day interval following the July 28-August 4 period could very well be animals which had contracted the disease during this interval, or even during the July 28-August 4 period. On the other hand, the possibility cannot be dismissed that these animals returned to graze in the two heavily contaminated meadows where the greatest number of dead animals was found originally.

At some places in the contaminated area the number of dead male animals exceeded greatly the number of dead females. This is due to the fact that bulls, isolated from the herds, died at or near favorite wallows in more or less restricted locations. The herd sex ratio is approximately 70 females to 30 males, and therefore dead males did not predominate in some areas frequented by the herds. Also, because the herds move about more than the isolated males, fatalities from the herds were scattered over a larger area. It is surmized that the behaviour pattern of the bison under natural conditions is an important factor in the epizootiology of the disease. Of interest is the fact that the disease did not occur in young animals to the extent that it did in older ones. Only one calf and two yearlings were found dead.

Considering the course of the epizooty and the number of animals affected in a relatively short period of time at localized spots in a rather limited area, there is no doubt that local factors, such as the low-lying and marshy nature of the area and the climatic conditions prevailing there during the 1962 summer when precipitation was high, favoured the occurrence of the outbreak. This outbreak was, and still is, the cause of much concern because of the relative proximity of the contaminated area to Wood Buffalo Park and because this particular area lies within the migration range of one herd of caribou. In view of the epizootiology of anthrax, the ecology of its aetiological agent, the location and size of the contaminated area, the wildlife species involved or that may be involved, it is evident that animal life in the area must be kept under close surveillance in the years to come to detect any signs of the disease.

SUMMARY

In July and August 1962, 281 bison, from herds totalling some 1,300 animals, died of anthrax in an outbreak of unknown origin in a 700-square-mile area in the region of Hook Lake in Canada's Northwest Territories.

The disease occurred in an acute and rapidly fatal form, as well as in a less acute form with many animals recovering. Symptoms are described, and lesions observed at the examination of animals that were shot or that died naturally are reported. The aetiological agent was isolated through guinea pig inoculation of material from animals that were shot. Steps were taken for the proper disposal of the cadavers and the area was quarantined. Survivors were herded and dispersed north and south of the contaminated area. However, a few weeks later a large number of them had returned.

The great majority of the dead bison were mature animals, the over-all sex ratio being 59 males to 41 females. However, the dead animals were mostly isolated bulls which make up a large percentage of the breeding stock. It is concluded that in addition to local influences, the behavior patterns of the bison were a factor of importance in the epizootiology of the disease in this outbreak.

This outbreak was, and still is, the cause of much concern because of its proximity to Wood Buffalo Park and because this area lies within the migration range of one herd of caribou. It is evident that the area will have to be kept under close surveillance in the years to come.

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DISCUSSION

PROFESSOR DAVIS: In regard to those 21 horses, even though to date you have not found any evidence that would incriminate these animals, do you think that there is a probability that they are responsible for this outbreak?

DR. CHOQUETTE: Personally, I don't think the horses have been at fault.

DR. TIERKEL: Where did the horses come from?

DR. CHOQUETTE: From Alberta and from an area where there is no history of anthrax.

PROFESSOR DAVIS: When these bison were removed from the area, in an anthrax outbreak there would be a certain amount of self-vaccination. In talking about isolation, and here you had a large population of animals coming down with the acute and, as I recall, subacute cases of anthrax—I was wondering about the advisability of movement of these animals. Would you care to comment on that?

DR. CHOQUETTE: In the circumstances we felt it was the best thing to do—to keep apparently healthy animals off the contaminated area.

DR. TRAINER [Wisconsin]: Did you have any deer or other species in this area, and were there any other animals found that you suspected of dying of anthrax and was there any human complication in this particular outbreak?

DR. CHOQUETTE: There was a human case which was not bacteriologically confirmed but all indications were of anthrax. This individual was treated and he recovered. There was also mention of a second case of anthrax in a human, but here again there is no clear-cut evidence of the case. Also there is a report of animals other than bison which are supposed to have died of anthrax but there was no bacteriological examination made of these animals. We intend to examine the carcasses of these animals.

MR. ROSS: In India there are irregular outbreaks of anthrax among the Great Indian Rhino, especially those in national parks. Do you feel that it is possible with present know-how to do something in a heavily populated country, such as India, to reduce or eliminate anthrax among Rhinos?

DR. CHOQUETTE: I don't know if I can give you a clear-cut answer to that question. In our case, we try to keep the animals out of the contaminated area. It will not be easy to do because it is a big area, several hundred square miles. We planned first to burn the whole area, but we did not succeed because of rain and also because much of the area is marshy. What we will do exactly in the future is not determined yet. Fencing of the area is not practical.

DR. KARSTAD: Dr. Choquette, I have a question I would like to ask. You mentioned the possibility of the influence of soil types, or at least alluded to an examination of soil, and we, knowing something of anthrax, realize that this is very important as to whether or not the soil will continue to be a reservoir of infection for wildlife in an area. I don't know what types of soil may be best suited for long-term survival of anthrax spores, or does the type have any bearing on this? If type has a bearing, then my next question is, do we have in this area suitable soil types to make us suspect that we will have a long-term problem here?

DR. CHOQUETTE: It is known that some types of soil favor the maintenance of anthrax spores. I don't know what types of soil we have in this area but we do have low marsh land which is recognized as satisfactory for the maintenance of spores.

TECHNICAL SESSIONS

Tuesday Morning—March 5

Chairman: Lee K. Nelson
Chief Wildlife Research Biologist, Kentucky Department of Fish and Wildlife Resources, Frankfort

Discussion Leader: Wayne W. Sandfort
Chief of Game Research, Colorado Game and Fish Department, Denver

FIELD AND FARM RESOURCES

STATUS OF THE FOREIGN GAME INTRODUCTION PROGRAM

Gardiner Bump
Bureau of Sport Fisheries and Wildlife, Washington, D. C.

The history of progress is a story of changes, in environment, in attitudes, in methods, in materials and in understanding. Only the truth is static and, even here what is considered true today may have to be modified tomorrow under the scrutiny of history.

It is with this basic assumption in mind that the International Association of Game, Fish, and Conservation Commissioners, the Wildlife Management Institute and the U. S. Fish and Wildlife Service, reviewed the history, the implications and the unsatisfactory status of attempts to acclimatize game birds and mammals in the United States and decided to establish a modest Foreign Game Introduction Program.

Organization and Operation

The thinking behind this action was documented before the North American Wildlife Conference in 1951, in a paper titled ''Game Introductions—When, Where and How.'' Since then the situation has not changed. Year by year the number of individuals seeking relaxation through hunting is increasing. Yet the area available for this sport is slowly decreasing. Likewise, much of the habitat which mothers the game crop is becoming less and less able to produce shootable surpluses under the impact of clean farming, overgrazing, drainage, power equipment, increased use of insecticides and herbicides, scientific forestry, urbanization, and declining soil fertility. Faced with this situation, common sense dictates an all-out effort to increase habitat productivity. But there are many habitats which have been so thoroughly changed by man that native game species can no longer maintain themselves therein in numbers sufficient to provide good hunting. Competing interests and the cost of reversing this trend are such that only a part of these lands can be restored to reasonable productivity in the foreseeable future. There are other coverts which never were fully occupied by native game birds or mammals possessing the characteristics requisite to survival in the face of today's intensive hunting pressure. For these, new adapatable species possessing a high hunting resistance should be sought so that such areas might provide hunting opportunities greater than is now possible. This is the logic behind the Foreign Game Introduction Program.

This Program is based on requests for assistance from State Commissions following a detailed ecological appraisal of their game-deficient habitats. After analyzing these, Federal biologists are assigned to make a careful study of game species occupying similar habitat and climatic niches in foreign countries. From dozens considered, a few may then be selected on the basis of their characteristics, habits, reproductive capacity, resistance to predation and disease, relationship to agriculture, ability to withstand heavy hunting pressure, and the possibility of competition with game species native to the United States. Modest carefully-planned trial introductions of these species, utilizing wild-trapped or hand-raised individuals, carefully conditioned and quarantined for 2 months before shipment and for 3 weeks following their arrival, are then carried out in cooperation with interested State Fish and Game Commissions. Unplanned or "hit and miss" introductions are actively discouraged.

The Foreign Game Introduction Program has remained, as it began, a slow, careful searching for and evaluation of new species to supplement the old. Quiet failures have been interspersed with equally quiet successes. After a slightly stormy start, neither the predictions of dire consequences nor of flashy results have come to pass. This is encouraging for one slip might have been disastrous; one striking success could have put the program behind the eight-ball of the sportsman's vibrant enthusiasms. The climate for conducting a piece of research has been good.

Program acceptance has been substantial. Cooperative agreements with 45 of the 50 States have been signed. Most of these States, at our request, have prepared written ecological descriptions and appraisals of their problem habitats as a basis for determining the character and extent of the areas they consider to be game-deficient. The area thus classified covers about 1/5 of the United States. All parts of the country are represented.

Problem habitats frequently mentioned indicated that a bird that might thrive in the following covers was desired by a number of States:

1. Deep, semi-mature northern forests.
2. Northern semi-cultivated uplands.
3. Southern woodlands below the range of ruffed grouse abundance.
4. Croplands below the range of the ring-necked pheasant.
5. Grasslands, moderately to heavily grazed.
6. Southwestern range lands.
7. Rough, mountainous areas outside of habitat occupied by the chukar.
8. Western range and croplands covered with snow in winter and not well-occupied by grouse or pheasants.

Particular interest was expressed in locating a ring-necked pheasant that might survive in the South or Southwest and a Hungarian partridge that might live in the East or below current gray partridge range. Theoretically this is not impossible for in Asia pheasants are abundant in coverts similar to those occupied by ringnecks in the United States and under temperatures and precipitation characteristic of many southern or southwestern potential game habitats. In fact, substantial progress already has been made in securing candidate species for trial in many of the cover types mentioned above. Incidentally program personnel have spent months afield with State biologists familiarizing themselves with these areas. Excluded from consideration are any where native species are able to maintain themselves in an abundance normally sufficient to provide good hunting opportunities.

In search of these, over the past 15 years, about a hundred species or subspecies of game birds in Europe and Asia have been screened. Based on studies made in their native habitat, only 20 of these have been recommended for consideration, either for trial release or for experimental propagation. Four of these, the capercaillie, blackcock, Spanish and French red-legged partridge, are resident in Europe.

Twelve of these are found in southern Asia. Included are the eastern and western Iranian, Afghan white-winged, and kalij pheasants, red junglefowl, Turkish chukar, Turkish gray and seesee partridges, black and gray francolin and the Indian and imperial sandgrouse. The Far East is the home of four others, the Japanese green, Korean and Reeves pheasants, and the bamboo partridge.

The problem of securing these birds in numbers sufficient to provide for a sound trial has not been easy. Two methods have been pursued. When birds were accessible and available in large numbers, they were wild-trapped, conditioned, quarantined twice and shipped to the States usually for direct release. When birds, even though abundant, were procurable only with great difficulty, small numbers were hand-raised from wild-collected eggs or chicks and sent to selected State game farms for experimental propagation. Over the past three years alone, 16,145 wild-trapped birds have been delivered to States requesting them for trial release for propagation. From the breeders thus provided, 54,259 individuals are reported over the same period to have been reared on game farms to supplement existing releases of wild-trapped stock or to provide additional birds for fresh trials. All species mentioned above, excluding only the grouse and the sandgrouse, are currently being reared in numbers sufficient to allow from limited to large trial liberations.

RELEASES, LIBERATION AREAS AND FOLLOW-UP TECHNIQUES

Trial liberations of 16 species or subspecies and 5 pheasant crosses are currently underway in 23 States and Guam. Twelve of these are farm and adjacent brush or waste lands species. Ten of the twelve are pheasants. Six are potentially adaptable to range and dry or irrigated farmlands; three are woodland species. Areas in which these are being tried lie mostly in the central, southern, southwestern and Pacific Coast States.

Release areas were, by necessity, selected mainly by State biologists, largely from photographs and written description of habitat, climate and other conditions existing within the native range of the species. If adequate weather records were obtainable, climacurvic comparisons of temperature and precipitation characteristic of the range and of the States interested in a species were provided. Available also for reference were over 60 progress or species reports. Still the areas selected varied from completely suitable to unsuitable, so program biologists are now attempting to evaluate each area in advance of the proposed release.

One substantial but still imperfectly understood cause of past failures has been the liberation of too few birds over too short a period of time. The minimum number that might constitute a sound test varies, of course, with the species under consideration. In general we have considered that at least 200 to 300 wild-trapped birds, or 3 to 4 times that number of game-farm reared individuals should be liberated in a single area each year for at least 3 years. In the past, releases of this size and duration were uncommon. The number of birds put out on an area in one year has varied from 11 to over a thousand. Repeated liberations often were the exception rather than the rule but the situation is now rapidly changing for the better.

State biologists have also experienced some difficulty in checking-up on release results. Planned, periodic, follow-up studies are an integral part of any well run acclimatization program. But biologists are always busy, and birds released in new surroundings often wander widely, though less so if the gentle-release method is employed. Time is required for technicians and local residents to learn the call and habits of a new species and to set up and carry out a variety of follow-up techniques. Few States have been able to assign trained personnel for more than 2 to 4 weeks in a year to the evaluation of results on any one area. Some States have done remarkably well, utilizing a combination of regularly scheduled call counts, farm contacts, and field observations, often with the aid of a dog. Others have carried out but little follow-up work.

RESULTS TO DATE

As to results, in most cases it is still much too soon to evaluate the liberations in terms of success or failure, but guarded optimism on the chances of establishment of several species or sub-species is justified. The initial attempt, on which the Program cut its eye teeth, was the introduction of the capercaillie (*Tetrao urogallus*). Only about 25 hand-raised birds were secured and these were liberated under conditions not conducive to success. All birds disappeared within two years. The second project, with Turkish chukars (*Alectoris graeca cyproites* and *kurdestanica*) was well-organized and carried out. Over 3,000 wild-trapped birds were sent to three States for liberation over a 4 year period. State cooperation was excellent and the birds were well-handled and followed subsequent to release. Those in Utah have become integrated with their Indian counterparts; in Arizona, after several inconclusive years, they disappeared. Only in New Mexico have they shown promise of survival, and there, in but a few localities. Common Indian sandgrouse (*Pterocles exustus hindustan*) secured in numbers with the assistance of Glen Christensen of the Nevada Commission, disappeared there but are still to be found in Hawaii.

On the other hand the search for a true pheasant that might thrive in the South and Southwest has turned up three promising possibilities. In Iran the western Iranian pheasant (*P. c. talischensis*) is abundant where temperatures range from a little above or below freezing in winter to 95° F. in summer with an annual precipitation of 30 to 60″ a year. The eastern Iranian pheasant (*P. c. persicus*) is found where temperatures range from 20 to 40° F. in winter and 90 to 100° F. in summer and yearly precipitation is 15 to 30″. Its counterpart in Afghanistan is the white-winged pheasant (*P. c. bianchi*). It lives under temperatures of 90 to 105° F. in summer and from 0 to 35° F. in winter where snow is not uncommon. Broods of Iranian pheasants, either in pure strain or crossed with the northern or Chinese ringneck, have been observed for several years on liberation areas, recently established in several southern States. Iranian pheasants, liberated four years ago have become sufficiently abundant in Virginia as to justify either a limited open season or trapping for restocking elsewhere in the State.

Missouri also reports encouraging results from liberations made in 1959 of hand-raised Iranian pheasants, crossed with northern ringnecks. Japanese green pheasants (*P. c. robustipes*) reproduced rapidly following liberation on Virginia's eastern shore. Gray francolin (*Francolinus pondicerianus*) are maintaining good populations on Lanai in Hawaii and are showing promise in Nevada. Black francolin (*Francolinus francolinus asiae*) appear to be on the increase in Louisiana. Eight other species, now being reared on State game farms have been or are about to be liberated in numbers sufficient to constitute fair trials always providing the birds are properly reared and conditioned for survival in the wild before release.

Experience indicates that a word of caution is necessary in evaluating results. Even though a species is thoroughly capable of survival in new habitats it fails, more often than not, for one or more of the following reasons:

1. It was not liberated in the proper habitat or by the proper methods.
2. If wild-trapped it was not in good condition when liberated.
3. If farm raised it was not properly reared and conditioned before release.
4. Too few were liberated at one time or releases were not repeated over a period of several years.
5. Protection against heavy losses from predation or hunting was not adequate.

In referring to releases even simple words like success or failure are less often applicable than is generally realized. For example close to the turn of the century about 5,000 pheasants were turned loose in the coverts of New York State. A State report for 1908 indicated that the birds had disappeared and that the experiment was a failure. Twenty-five years later the annual pheasant kill in this State exceeded 200,000 birds. Likewise, attempts to introduce the European rabbit into Australia were continued for 71 years before, unfortunately, the species succeeded in establishing itself. In evaluating results a period of from 5 to 20 years is none too long to wait before a new species can be accurately described as successful or as a failure.

In summary the present Program is as carefully planned and as scientifically operated as Bureau and State biologists can make it. The need for such a program is indicated, not only by the past and present history of attempts to introduce game species, but also by the cooperative agreements signed and ecological appraisals submitted by all but 5 of the 50 State Conservation Commissions. It is too soon to speak of results except in terms of indications of ultimate success or failure. Guarded optimism for eventual success with some species, premonitions of failure with at least one, seem justified. Nor have the fears expressed by some, when the Program was undertaken, been realized. So far as is known no diseases, new to the United States, have been imported, no cases of hybridization with existing game birds recorded, no native species crowded out. Bobwhites still call from field borders in Virginia where pheasants have multiplied. In Louisiana, State biologists watched bobwhite and black francolin call from adjacent fenceposts for over a month with no signs of antagonism. When flushed the quail would fly into a brushy patch, the francolin into a soybean field. In fact, reports of francolin travelling in apparent harmony with a covey of quail in winter are not infrequent. But the francolin generally are reported to utilize different foods, nesting and resting cover, found in this case, within the range of quail but not particularly attractive to them.

Gibbons, in writing his famous "History of the Decline and Fall of the Roman Empire" remarks that "a crowd of critics, of compilers, of commentators darkened the face of learning." The same holds true about exotics and will until we apply science and common sense to the problem. Many biologists believe that the current Program is a long step in this direction.

DISCUSSION

MR. JAMES HILL [Wisconsin Conservation Department]: I would like to ask your opinion of the Finnish race of the Hungarian Partridge as a bird adaptable to the United States.

DR. BUMP: The Finnish race will live farther north than does the Hun in Central Europe. I would, however, think it is so relatively close to the Polish and Hungarian distribution area of the Hungarian Partridge that I would very much prefer to go much farther east into Siberia.

In 1959 we visited the USSR and spent about three weeks there to see if we could obtain six species of game birds that have never been brought out to the Western World before. Three of those were species or subspecies of *Perdix.* I think you would have been particularly interested in it. Unfortunately, just two weeks before they were to be sent to the United States the U-2 incident and the Summit Conference blew up in our faces and the result was that we didn't get our birds. Anytime the political climate becomes mild enough to permit us to get to Siberia, we will go.

Your question about species adapted for trial in the Northern United States poses a very difficult problem for us. There aren't too many places left in the world where we can look for game birds. For example, South Africa runs only down to about 32 degrees south unless you get into the high altitudes. We will perhaps be working for the next two or three years looking for grass-oriented birds in the Argentine. That runs as far south as Hudson Bay is north. However, we have no idea yet whether we will find any bird that will look like a possibility for the northern climate.

Except for the Southern Argentine and for a few of the mountainous areas of Ethiopia, I am afraid that we are going to have to get into Northern China or Siberia or the north of Russia before we can find additional birds that might be introduced to the northern states. We have the Korean pheasants which are already being tried.

At the last meeting we had when the subject of bringing in exotic birds was brought up, there was a group of people who took the position that they wanted nothing new as far as birds were concerned. Their greatest fear was that a new bird might hybridize with our native species but we have been very careful in checking these things and to date we have seen no evidence of that problem.

RATING NORTHEASTERN SOILS FOR THEIR SUITABILITY FOR WILDLIFE HABITAT

PHILIP F. ALLAN, LLOYD E. GARLAND AND R. FRANKLIN DUGAN[1]

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Soil survey maps and related data apparently have not been used extensively by wildlife managers, if published records can be taken as an indication. The general absence of conformity to soil boundaries by the plant species that comprise much of wildlife habitats and the mobility of wildlife across such boundaries, perhaps, account for some of the difficulties of relating wildlife to soils. There is, however, a large body of soils data, accumulated by competent scientists, that, with appropriate interpretation, can contribute materially to wildlife conservation. We propose, here, to discuss a new tool for the wildlife manager. That is, the rating of specific soils for their suitability for management for several important northeastern wildlife habitat elements. From evaluation of various combinations of these habitat elements, we can get an approximate idea of the suitability of soil units mapped in soil surveys for open-

[1]Biologist and Soil Correlator (Northeastern States) and Biologist (Va.) respectively.

land, woodland or wetland wildlife. We must point out that the concept is still in developmental form. Other publications are planned to explain more fully the relationships of soils to habitats, and refinements are anticipated with more experience in using the technique.

PREVIOUS STUDIES

Most of the publications on wildlife-soils relationships deal in general terms with great soil groups or major soil associations. Certain relationships of wildlife distribution to soil regions and great soil groups were stated by Albrecht (1943). Toth (1955) covers some aspects of wildlife with reference to great soil groups in the Northeast. A number of reports from Missouri relate bodily dimensions and abundance of deer, raccoons, rabbits, muskrats, and oppossums, to soil fertility (See Denny, 1944; Crawford, 1950; Steen, 1955.) Crawford (1946) describes wildlife sampling by soil types and relates quail abundance to specific soils. Crawford (1950), relates soil fertility to fecundity in the fox squirrel. Cheatum's (1947) studies on New York deer show similar relationships. Ringnecked pheasant abundance and breeding success on fertile soils of limestone origin are discussed by Leopold (1931) and Dale (1954); while Leopold and Dalke (1943) report a striking correlation of wild turkey distribution with Clarksville stony loam. Kubota and Swanson (1958) point out the possibilities of health hazards to deer and moose living on cobalt-deficient soils.

Vegetation-soil maps were developed by Cronemiller (1955) for planning wildlife habitat developments in California. He also recommends the study of soil surveys as a background for wildlife development programs; and suggests the participation of wildlife technicians in making soil surveys.

Since 1958, biologists and soil scientists of the Soil Conservation Service in the Northeast have been collaborating in the development of soil survey interpretations for wildlife conservation. Dugan (1962) presents, in Soil Survey Report of Gloucester County, New Jersey, a tabulation of the suitability of soils for growing wildlife food and cover plants and for the management of small game, deer, waterfowl, furbearers and pond fish. Dugan also pioneered, and Allan and Garland refined the techniques, that provide the basis of this paper. Northeastern soil survey reports now in various prepublication stages contain wildlife habitat-soil ratings.

WILDLIFE HABITAT—SOILS RATINGS

Most managed wildlife habitats are created, improved or maintained by: (a) planting suitable vegetation; (b) manipulating existing vegetation; (c) inducing natural establishment of desired plants; or (d) by combinations of such measures. We hold that the behavior of soils can be predicted from knowledge of their properties. The growth habits and characteristics of plants that comprize wildlife habitat are affected by such behavior. Such interpretations can be applied to a variety of habitat elements and, from the appraisal of those elements, the suitability of a site for various kinds of wildlife, under specific soil conditions can be approximated.

At our present state of knowledge we are not prepared to say that soil condition A will produce more or larger pheasants than soil condition B, nor even that pheasants will occur on either. We are, however, prepared to say that A, in general, is better suited than B for the management of a habitat element that, within pheasant range, is important to the species.

USES OF RATINGS

Several purposes may be served in wildlife conservation by wildlife habitat-soils ratings. First, such ratings provide an aid in the selection of sites for habitat management. Secondly, they furnish indications of the extent or degree of management intensity needed to produce satisfactory results. Thirdly, the ratings provide a means of grouping known soil conditions for broad-scale wildlife land use planning, for wildlife land acquisition and for park and other recreation developments. The ratings are an aid in showing landowners, in conjunction with soil survey maps of their properties, places where management measures for desired wildlife are best applied and in helping them in their selection of practices. They may also be useful in showing why certain desires for, let us say, pheasants may not be feasible. Wildlife habitat-soils ratings, as discussed in this paper are now being included in the SCS Technical Guides.

TO AVOID CONFUSION

It is essential to an understanding of the ratings to make clear certain points. Present land use and existing vegetation are not considered in the rating system. These factors are subject to change. Important as they are to the wildlife manager in detailed planning, there is no practical method of determining them from a soil survey.

The soil areas outlined on soil survey maps are rated without regard to positional relationships with adjoining delineated areas. The size, shape or location of the outlined area does not affect the rating.

The ability of wildlife to move from place to place also is disregarded. This is because the wildlife species is not directly rated, while habitat suitability is.

Numerous other kinds of interpretations can be made from a given set of soils data, as for food or fiber crop production, livestock forage production and timber production. These interpretations have little or no direct bearing on the wildlife habitat-soils interpretation; although there may be some parallels. Rating criteria applicable only to wildlife habitat have been used. Thus, for instance, a soil condition suitable for rapid height growth and quick canopy closure of coniferous trees—a situation desirable for timber production—is rated as poorly suited for coniferous wildlife habitat.

MAKING THE RATINGS

Ratings are made in two major steps, as described in more detail below. First, the soils are rated in terms of suitability for habitat elements. Next, various combinations of habitat elements are weighed for their significance to, and rating for, general classes of wildlife.

The soil type and phase, here called a detailed mapping unit, presently appears to be a more useful basis for rating suitability for wildlife habitat than soil associations.

In the Northeast, there are many hundreds of soil types and many thousands of phases. We do not have the background of experience to enable us to rate all of these soils individually. Soil scientists of the Northeast have selected certain soils that represent the range of of all mapping units. These soils provide a standard frame of reference and are termed bench mark soils. The bench mark soils are now being used for interpretations in such fields as agronomy, forestry, engineering, sanitation and zoning, as well as for wildlife.

We have assigned ratings for bench mark soils covering 119 soil series and land types and about 900 mapping units. These large numbers provide representation for most soil conditions to be found in 12 northeastern states.

Habitat Elements

Eight habitat elements were selected for rating. These are:

Grain and seed crops. Domestic grains or seed-producing annual herbaceous plants, planted to produce wildlife foods.

Examples: corn, sorghums, wheat, millets, buckwheat, cowpeas, soybeans, sunflowers.

Rating Criteria:

1. Soil conditions suitable for repeated annual planting, individually, in combination, or in rotation of any or all climatically adapted species, without intervening sod crops for soil protection and maintenance.
2. Soil conditions suitable for the planting, individually, in com-

bination, or in rotation, of any or all climatically adapted species but requiring a rotation with sod crops up to 66% of the time for soil protection and maintenance.

3. Soil conditions suitable for the planting, individually, or in combination, of any or all climatically adapted species but requiring a rotation with sod crops more than 66% of the time for soil protection and maintenance.
4. Under prevailing soil conditions, grain and seed crops cannot be grown or it is not feasible to plant them.

Grasses and legumes. Domestic perennial grasses and herbaceous legumes that are established by planting and furnish wildlife cover and food.

Examples: fescues, bromes, timothy, redtop, orchard-grass, reed canarygrass, clovers, trefoils, alfalfa, sericea lespedeza.

Rating Criteria:

1. Soil conditions suitable for planting of a wide variety of climatically adapted species; and the maintenance of adequate stands for wildlife cover for at least 10 years without renovation or fertilization.
2. Soil conditions suitable for planting of a wide variety of climatically adapted species; but the maintenance of adequate stands for wildlife cover for at least 10 years requires renovation, liming or fertilization.
3. Soil conditions suitable for a very limited number of species, generally not more than one or two; but where natural vigor of stands may be high without renovation, liming or fertilization.
4. Soil conditions that have severe limitations as to suitability for a variety of species and for vigor of growth; producing very sparse stands; and where renovation liming and fertilization are impossible or impracticable to apply.

Wild herbaceous upland plants. Native or introduced perennial grasses and forbs (weeds) that provide food and cover principally to upland forms of wildlife; and are mainly established through natural processes.

Examples: bluestems, Indiangrass, wheatgrasses, wild ryes, oatgrasses, pokeweed, strawberries, lespedezas, beggarweeds, wild beans, nightshades, goldenrods, dandelions.

Rating Criteria:

1. Soil conditions suitable for the establishment and vigorous growth of a wide variety of uncultivated species.
2. Soil conditions which limit the variety of species but on which growth of only a few species may be vigorous.

3. Soil conditions suitable for the establishment of very few species; and vigor of growth limited.
4. Soil conditions where variety of adapted species is so restricted, stands so sparse and vigor so poor as to be of insignificant value to wildlife.

Hardwood woodland plants. Non-coniferous trees, shrubs and woody vines that produce fruits, nuts, buds, catkins, twigs or foliage used extensively as food by wildlife; and which commonly are established through natural processes but also may be planted.

Examples: oaks, beech, cherries, hawthorns, dogwoods, viburnums, hollies, maples, birches, poplars, grapes, honeysuckles, blueberries, briers, greenbriers, roses.

Rating Criteria:

1. Soil conditions suitable for the vigorous growth and dependable food production from a wide variety of climatically adapted species.
2. Soil conditions suitable for most climatically adapted species but annual dependability of food production somewhat limited.
3. Soil conditions suitable to few species of importance to wildlife for food production and annual food production usually low.
4. Soil conditions under which very few or no species of importance to wildlife will grow and where growth is so sparse as not to be of significance to wildlife.

Coniferous woodland plants. Cone-bearing trees and shrubs, primarily of importance to wildlife as cover but which also may furnish food in the form of browse, seeds or fruit-like cones; and which commonly are established through natural processes but also may be planted.

Examples: pines, spruces, white cedars, hemlock, balsam fir, red cedar, junipers, yews.

Rating Criteria:

1. Soil conditions suitable for a variety of climatically adapted species but on which growth is retarded; canopy closure delayed.
2. Soil conditions suitable for a limited number of species; growth rate slow to moderate.
3. Soil conditions suitable for most or all climatically adapted species; growth rate and canopy closure rapid.
4. Soil conditions suitable for few or no species; stands so sparse as to be insignificant to wildlife.

Wetland food and cover plants. Annual and perennial wild herbaceous plants of moist to wet sites, exclusive of submerged or floating aquatics, that produce food or cover extensively used mainly by wetland forms of wildlife.

Examples: smartweeds, wild millets, bulrushes, spike sedges, rushes, sedges, burreeds, reeds, wildrice, rice cutgrass, switchgrass, mannagrasses, bluejoint, cordgrasses, saltgrass, cattails.

Rating Criteria:

1. Soil conditions suitable for the growth of a wide variety of climatically adapted species, particularly food producing annual plants.
2. Soil conditions suitable for a wide variety of species, particularly perennials.
3. Soil conditions that tend to produce dominant stands of a few vigorous perennial species, generally of low food production value.
4. Soil conditions under which wetland plants do not grow or are so sparse as to be of no significance to wildlife.

Shallow water developments. Impoundment or excavation of areas or control of water generally not exceeding 5 feet in depth.

Examples: low dikes and levees, shallow dug-outs, level ditches, devices for water level control on marshy streams or channels.

Rating Criteria:

1. Soil conditions under which there are few or no limitations in the construction of shallow water areas and control or maintenance of desired water levels.
2. Soil conditions under which there are moderate limitations in construction, choice of measures, or some difficulties in water level control.
3. Soil conditions that severely limit choice of measures, present serious construction problems or major difficulties in water level control.
4. Soil conditions under which shallow water developments are impossible or not feasible.

Excavated ponds. Dug-out water areas or combinations of dugout and low dikes (dammed areas), which have water of suitable quality, of suitable depth and in ample supply for the production of fish or wildlife.

Example: pond of at least 1/10 acre surface area and average depth of 6 feet over at least ¼ of the area; and having a dependably high water table or other source of unpolluted water of low acidity.

Rating Criteria:

1. Soil conditions under which suitable locations for excavated ponds are common, adequate water supplies readily available and having few or no construction problems.
2. Soil conditions under which it is somewhat difficult to locate suitable sites; satisfactory water supplies may be somewhat

undependable; or on which there may be moderate construction difficulties.

3. Soil conditions under which the location of suitable sites is difficult; satisfactory water supplies are undependable or there may be serious constuction difficulties.
4. Soil conditions under which excavated ponds cannot be built or are not feasible.

Rating criteria for each habitat element were established on a 3 level scale of suitability. Soil conditions unsuitable for each habitat also were established. The rating levels are numbered and defined as follows:

1. *Well Suited*: Habitats, on soils so rated, generally are easily created, improved or maintained. There are few or no soil limitations in habitat management and satisfactory results are well assured.
2. *Suited*: Habitats usually can be created, improved or maintained on these soils but there are moderate soil limitations that affect habitat management. A moderate intensity of management and fairly frequent attention may be required to assure satisfactory results.
3. *Poorly Suited*: Habitats can usually be created, improved or maintained on these soils but there are rather severe soil limitations. Habitat management may be difficult, expensive, and require intensive effort. Results are questionable.
4. *Unsuited*: This rating indicates that habitats cannot be created, improved or maintained, or it is impractical to attempt to do so under the prevailing soil conditions. Unsatisfactory results are probable.

Soil Properties and Limitations

The soil properties that through their behavior impose limitations with respect to plant growth or water management were determined. Those properties considered to pertain to the rating criteria were as follows: (1) effective depth of bedrock or hardpan; (2) surface texture; (3) available moisture holding capacity to a 30 inch depth; (4) natural drainage stage; (5) surface stoniness; (6) hazard of flooding; and (7) the range of slope in per cent. Properties which impose limitations for each habitat element were tabulated. The properties of bench mark soils were compared to the list of limiting factors for each habitat element and a rating was made for each mapping unit of the bench mark soils.

There are many cases where a single soil property, such as effective depth, may be the over-riding limitation for a specific habitat element. In other cases, however, more than one soil property will combine to set the limitation and, in some instances, combinations of soil properties may offset a limitation. Combined judgment of a biologist and soil scientist will resolve these problems.

Combining Habitat Elements for Kinds of Wildlife

The ratings of suitability of soils for kinds of wildlife were made on the basis of weighted values assigned to a selection of habitat elements appropriate to the kind of wildlife. For example, grain and seed crops, grasses and legumes and wild herbaceous upland plants were given a greater weight than hardwood woodland plants as habitat elements for the wildlife of openland. All four elements, however, were considered important to that kind of wildlife (Figs. 1b 2 and 3).

The following definitions were used for the kinds of wildlife:

Openland Wildlife. Birds and mammals that normally frequent croplands, pastures, meadows, lawns, and areas overgrown with grasses, herbs and shrubby growth. Examples: quail, pheasants, meadowlarks, field sparrows, redwinged blackbirds, cottontail rabbits, red foxes, woodchucks.

Woodland Wildlife. Birds and mammals that normally frequent wooded areas of hardwood trees and shrubs, coniferous trees and shrubs or mixtures of such plants. Examples: ruffed grouse, woodcock, thrushes, vireos, scarlet tanagers, gray and red squirrels, gray foxes, white-tailed deer, raccoons.

Wetland Wildlife. Birds and mammals that normally frequent wet areas such as ponds, marshes and swamps. Examples: black ducks, wood ducks, rails, herons, shore-birds, mink, muskrats, beavers.

Extending Bench Mark Ratings to Other Areas.

To apply this rating procedure to a specific area in the Northeast the soils are first arrayed by soil scientists in accordance with the relationship of their properties and behavior to those of selected bench mark soils. Soil scientists and biologists collaborate in agreeing on the ratings for other than bench mark soils and, especially, on those whose properties and behavior are intermediate between two or more bench marks soils.

The following examples indicate how the soils shown in Figure 1a were rated based upon the effects of their soil properties on the specific wildlife habitat elements.

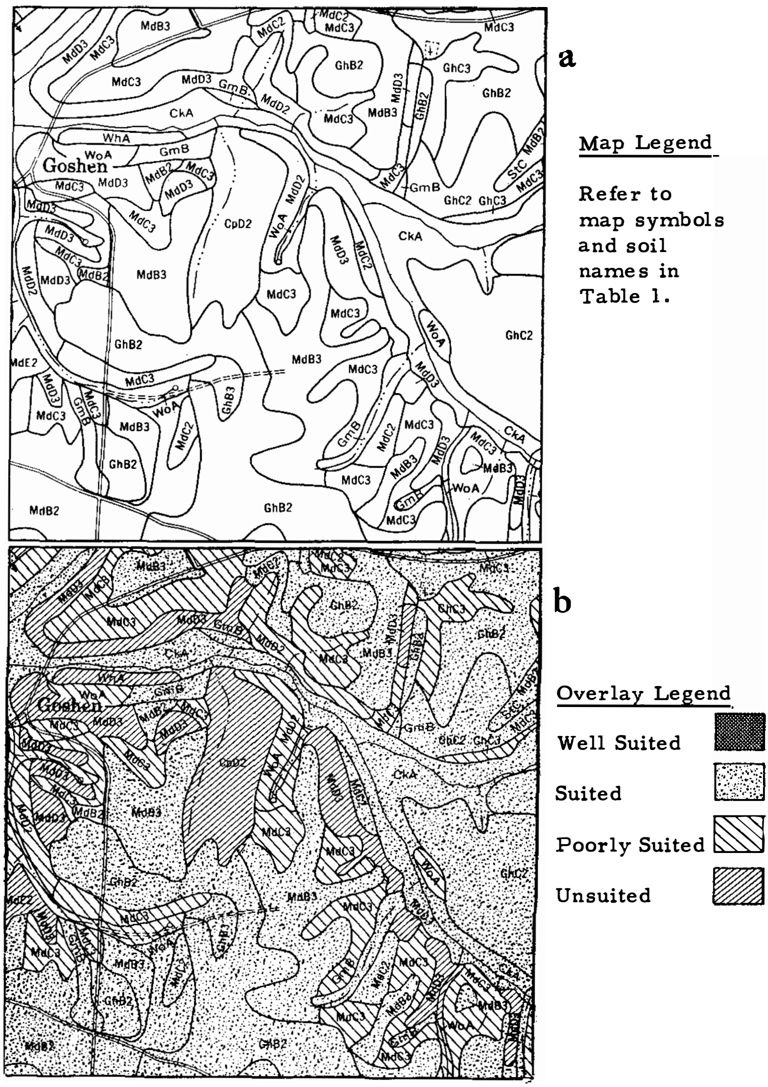

Fig. 1. (a) Square Mile Section of Map Sheet No. 16 from Soil Survey Report for Montgomery County, Maryland, and (b) Overlay Indicating Suitability for Grain and Seed Crops as an Element of Wildlife Habitat.

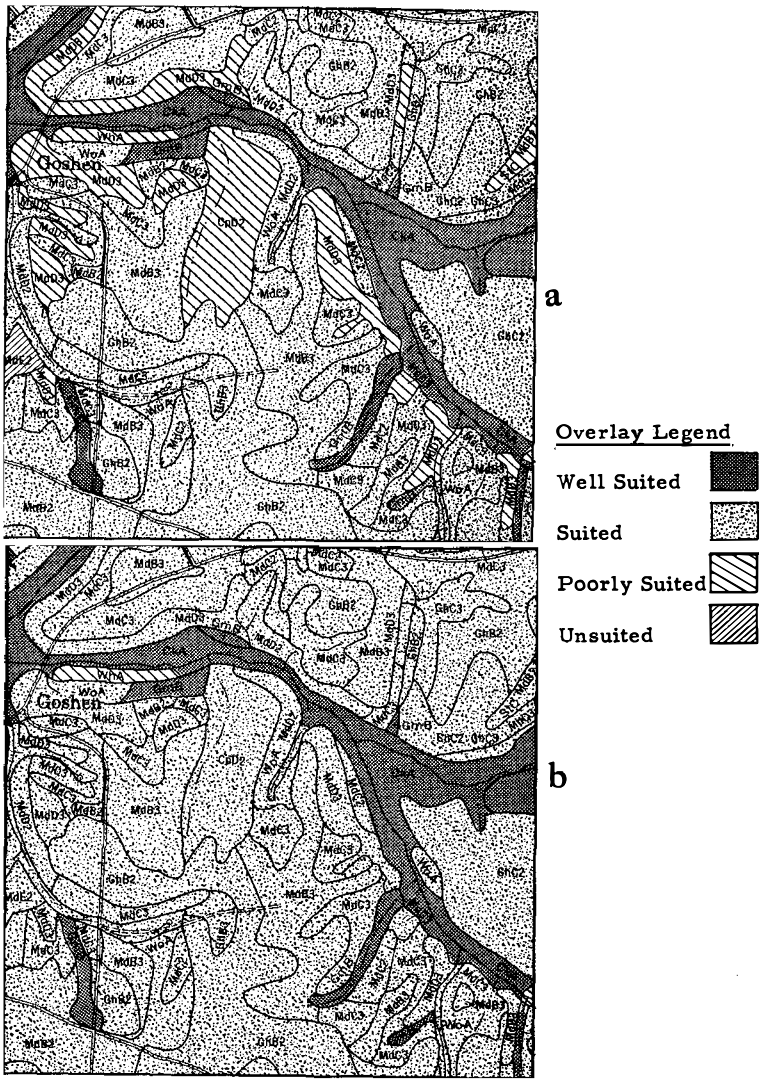

Fig. 2. These two overlays indicate suitability for (a) Grasses and Legumes, and (b) Wild Herbaceous Upland Plants as Elements of Wildlife habitat based upon the map section shown in Figure 1.

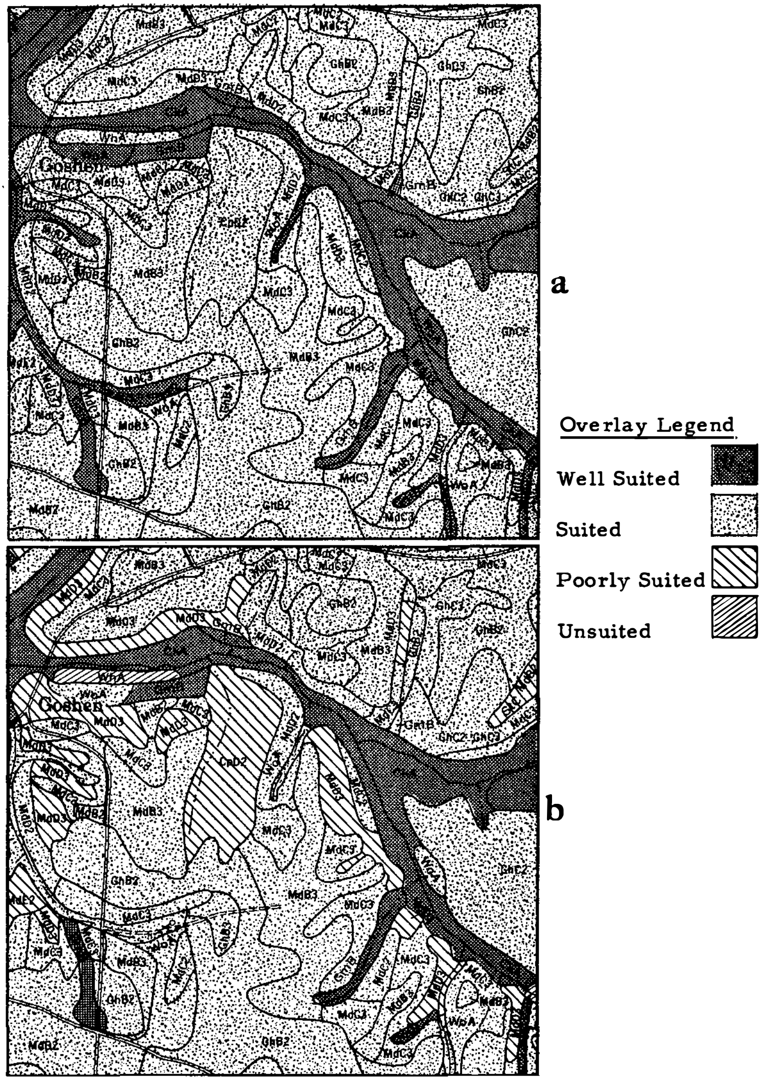

Fig. 3. These two overlays indicate suitability for (a) Hardwood Woodland Plants as an element of wildlife habitat, and (b) Openland Wildlife as the integrated habitat for the four habitat elements shown in Figures 1, 2, and 3, overlays based upon map section shown in Figure 1.

TABLE 1 - RATING OF SOILS[1/] FOR ELEMENTS OF WILDLIFE HABITAT AND KINDS OF WILDLIFE

Map Symbol	Soil Name	Wildlife Habitat[2/] Elements: Grain and Seed Crops	Grasses and Legumes	Wild Herb. Upland Plants	Hardwood Woodland Plants	Coniferous Woodland Plants	Wetl. Food and Cover Plants	Shallow Water Development	Excavated Ponds	Kinds of Wildlife: Openland Wildlife	Woodland Wildlife	Wetland Wildlife
CkA	Chewacla silt loam, 0 to 3 percent slopes . .	2	1	1	1	3	3	3	3	1	1	3
CpD2	Chrome very stony silt loam, 3 to 25 percent slopes, moderately eroded	4	3	2	2	2	4	4	4	3	2	4
EeC2	Elioak silt loam, 8 to 15 percent slopes, moderately eroded	2	1	1	1	3	4	4	4	1	1	4
GhB2	Glenelg silt loam, 3 to 8 percent slopes, moderately eroded	2	2	2	2	2	4	4	4	2	2	4
GhB3	Glenelg silt loam, 3 to 8 percent slopes, severely eroded	2	2	2	2	2	4	4	4	2	2	4
GhC2	Glenelg silt loam, 8 to 15 percent slopes, moderately eroded	2	2	2	2	2	4	4	4	2	2	4
GhC3	Glenelg silt loam, 8 to 15 percent slopes, severely eroded	3	2	2	2	2	4	4	4	2	2	4
GmB	Glenville[3/] silt loam, 3 to 8 percent slopes ..	2	1	1	1	3	4	4	4	1	1	4
MdB2	Manor[3/] silt loam, 3 to 8 percent slopes, moderately eroded	2	2	2	2	2	4	4	4	2	2	4
MdB3	Manor[3/] silt loam, 3 to 8 percent slopes, severely eroded	2	2	2	2	2	4	4	4	2	2	4
MdC2	Manor[3/] silt loam, 8 to 15 percent slopes, moderately eroded	2	2	2	2	2	4	4	4	2	2	4
MdC3	Manor[3/] silt loam, 8 to 15 percent slopes, severely eroded	3	2	2	2	2	4	4	4	2	2	4
MdD2	Manor[3/] silt loam, 15 to 25 percent slopes, moderately eroded	3	2	2	2	2	4	4	4	2	2	4
MdD3	Manor[3/] silt loam, 15 to 25 percent slopes, severely eroded	4	3	2	2	2	4	4	4	3	2	4
MdE2	Manor[3/] silt loam, 25 to 45 percent slopes, moderately eroded	4	4	2	2	2	4	4	4	3	2	4
StC	Stony land, Manor materials, 3 to 15 percent slopes	4	3	2	2	2	4	4	4	3	2	4
WhA	Wehadkee silt loam, 0 to 3 percent slopes . .	4	3	3	1	1	1	4	4	4	1	3
WoA	Worsham[3/] silt loam, 0 to 8 percent slopes .	3	2	2	1	2	1[4/]	1[5/]	1[5/]	2	1	1[6/]

1/ Based on Figure 1 - Square Mile Section of Map Sheet No. 16 from Soil Survey Report of Montgomery County, Md.

2/ Numbers indicate habitat suitability as follows: (1) Well Suited; (2) Suited; (3) Poorly Suited; (4) Unsuited.

3/ The underlined names indicate representatives of Northeastern bench mark soils.

4/ Slopes above 3 percent would rate 3.

5/ Slopes of 0-1 percent rate 1; slopes of 1-2 percent rate 2; slopes of 2-3 percent rate 3; slopes over 3 percent rate 4.

6/ The suitability for wetland wildlife would be adjusted when the ratings change in accordance with footnote[5/] for wetland food and cover, shallow water development and excavated ponds.

Glenville silt loam, 3 to 8 per cent slopes (GmB)

This gently sloping soil is deep and moderately well drained with a silt loam surface texture, high available moisture, no surface stoniness and not subject to flooding. It is rated *suited* for grain and seed crops, *well suited* for grasses and legumes, wild herbaceous upland plants and hardwood woodland plants; *poorly suited* for coniferous woodland plants; and *unsuited* for wetland food and cover plants, shallow water developments and excavated ponds.

Worsham silt loam, 0 to 8 percent slopes (WoA)

This level to gently sloping soil is deep and poorly drained with a silt loam surface texture, high available moisture, no or slight surface stoniness and not subject to flooding. It is rated *poorly suited* for grain and seed crops; *suited* to grasses and legumes and wild herbaceous upland plants; *well suited* to hardwood woodland plants; suited to coniferous woodland plants; and *well suited* to wetland food and cover plants, shallow water development, and excavated ponds on slopes of 0 to 1 per cent.

Table I summarizes the suitability ratings for the soils shown in Figure 1a for both wildlife habitat elements and kinds of wildlife. For detailed information about the soils in this table consult the Soil Survey Report for Montgomery County, Maryland, (Matthews, Compy and Johnson, 1961).

Figures 1b to 3b present over-lays showing the habitat suitabilities described above for a section of a map sheet (Figure 1a) taken from the published soil survey report for Montgomery County, Maryland. A study of the over-lays should suggest a number of wildlife management possibilities.

The ratings of the Northeastern bench mark soils are completed. It is now possible for wildlife biologists to work with soil scientists in applying this technique anywhere that soil surveys have been made in the region. With appropriate selection of habitat elements, development of rating criteria, and correlation with the properties of soils, we believe that the technique will prove useful elsewhere in the country.

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DISCUSSION

MR. ROLAND CLEMENT: I would like to ask Mr. Garland how many man hours are involved in working out the suitability classification for wildlife attraction.

MR. GARLAND: I could answer that facetiously but I will try to answer it precisely. There are a lot of man hours involved developing in this particular system. In fact, I am afraid to report all of the man hours spent on it. However, with the fact that we have rated these 119 soil series with all the related materials and, in the particular case of Connecticut, we have bracketed your soil conditions. The task of rating the soils in Hartford County, for instance, which, by the way, we have done, is relatively simple using this frame of reference. Actually, in the course of one to two days of a biologist's and soil scientist's time you could come up with these ratings for an entire county.

MR. CLEMENT: This is very important because my first impression was that I could walk this section and find out its suitability rather than doing it at the drafting table.

MR. GARLAND: There's something that I ought to mention that's very important and that I didn't touch on in the paper.

You can take a soil survey and rate the soils, although this does not take the place of on-site problems that you will have in dealing with wildlife management. We are not saying this. All we are saying is that this would give you general suitability before you go out and apply your wildlife techniques. I think it can be a very good time saver.

AUTOMATION IN WILDLIFE PROGRAMS—PRESENT AND FUTURE

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There is a great potential in automation for increasing the efficiency of the wildlife biologist and for making possible jobs that to date do not exist in wildlife management programs. The field of wildlife management and research is just beginning to utilize modern concepts of automation. The taking of notes in the field by pencil and paper is being replaced by portable tape recorders. The biologist transcribes his notes when he returns from the field. Such a machine will save at least 60 minutes of a biologist's valuable time each day while in the field; thus it will pay for itself in less than a month. In the lab, copies of reprints concerning new information can be run off on one of a number of types of copying machines and distributed to the entire staff of biologists, keeping everyone in the organization up-to-date. Volumes of data now can be handled automatically through punch cards and IBM computers. These machines can sort the data from a number of different approaches and in a very short time. Data, which once took months to put in orderly groups, can be sorted and integrated in minutes after the initial punching of cards.

A more mechanized approach is coming in basic ecological research and in the development of census techniques. The biologist will not be removed from the field, but a more efficient utilization of his time and an improvement in the data collected will result.

The biologist formerly had to be in the vicinity of an animal's home constantly to obtain data on care of young, incubation time, or the frequency and period of time of activity of an animal. Today, automatic means of detecting the presence, or absence, of an animal have been developed. The least expensive methods utilize thermocouples and automatic recording devices. Thus the time of day of incubation or nursing, the length of the period of incubation or nursing, the shift of individuals in parental care, the time of day of activity, the dates of birth of litters, as well as many other types of information can be determined with accuracy (Baldwin and Kendeigh, 1927; Stains, 1961). Similar types of information have been obtained through the use of automatically triggered cameras (Gysel and Davis, 1956; Pearson, 1959; Dodge and Snyder, 1960; Osterberg, 1962), tripped solenoids or microswitches (Kendeigh and Baldwin, 1930; Klonglan, Coleman, and Kozicky, 1956; Griffo, 1959), photoelectric cells (Yates, 1942), and radio-active materials (Griffin, 1952; Lachelt, 1954; Godfrey, 1954; Pendleton, 1956; Miller, 1957; Karlstrom, 1957; McCabe and LePage, 1958).

To study home range and movement, the biologist once had to live-trap, mark, and recapture animals. Today, miniature radio transmitters, attached to animals, can be used to locate animals (LeMunyan, White, Nyberg, and Christian, 1959; Marshall, 1960; Marshall, Gullion, and Schwab, 1962). Transmitters are being developed which are extremely small and emit a powerful signal (Cochran and Lord, 1963; Verts, 1963). From this step, it is within the realm of possibility that these signals could be picked up at a central headquarters on a control board and the data recorded 24 hours a day. A project is presently being planned which would utilize a portion of a space satellite to locate albatrosses carrying radios over the Pacific, thus pinpointing the travels of these wanderers (H. I. Fisher, personal communication, 1962). Warner (1963) also has indicated the possible use of satellites to follow Canada geese. The field of study of animal movement has, through the use of radio, been revolutionized, and many of our former opinions concerning home range probably will need to be revised.

Radios also have been used to study the temperature of eggs during incubation. A transmitter was inserted in an egg and the signal received by low frequency radio and an audio-frequency pulse-counting device (Eklund and Charlton, 1959). Numerous types of physiological processes are being recorded by this method; for example, pulse, body temperature, and blood pressure.

Little has been done to modernize our census techniques through the use of automatic devices. Almost all types of censuses involve tremendous expenditures of human effort and the results are often far from satisfactory. The use of aerial photography for censusing waterfowl, some forms of big game, and seals is probably the most successful modern form of census (Leedy, 1948). Such photos now can be taken automatically at high speeds and low altitudes (Anonymous, 1962). Greater advances in this field will be possible when the recently developed infra-red film is placed in an unclassified status. An example of the resolving power of this film, which is based on the sensitivity of the infra-red film to the radiation of heat, was revealed in the recent publication of pictures taken at extremely high altitudes over Cuba. In these it was possible to discern a man walking across a field from a picture taken from a height of approximately 15 miles. A herd of deer, even in a deciduous forest, should stand out like a beacon if pictures with infra-red film were taken in the winter.

Future development of census techniques should be along lines related to our sense organs as this is the means by which we detect and count animals. Much of which I am about to present is pure speculation but it is worthy of some investigation, I believe.

Research in the area of mechanical devices, which can record through stimulation by odor, has been almost entirely neglected. Such devices however are entirely within the realm of possibility. These instruments would probably be chemical in nature, thus the chemical content of such odors would need to be determined through extensive analysis (Jacobson, Beroza, and Yamamoto, 1963). Once the chemical content is known, instruments which would react to specific chemicals could be built. Industry at present is utilizing equipment which will warn of leakage of poisonous and explosive gases. Our own sense of smell is able to distinguish many odors as the sale of perfumes and detection of skunks will attest. We also know that each kind of animal has its particular natural scent and body odor which the species is able to detect and recognize. Apparatus which is sensitive to particular chemical odors could automatically record the passage of a particular species of animal. Such instruments could be placed along deer trails, for example, and provide a ready means of counting all the deer traveling these trails. Perhaps a chemically impregnated paper, such as litmus paper, could be developed sensitive to specific odors. Such paper could be inserted in ground dens to identify the species using the den.

Numerous census methods utilize the sounds made by animals. An automatic recording-listening apparatus is being used to identify birds during migration (Graber and Cochran, 1959). Instruments could be constructed which are triggered by the calls of various species. Thus, instead of the biologist driving about the country making periodic stops to listen for calls, automatic recorders could be placed in such habitats and be on constant watch. These machines, like the radios, could send the triggered signals back to a central office where counts covering large areas could be assembled. Thus calls of pheasant, quail, or dove and perhaps the drumming of grouse or the hum of the wings of doves could be automatically counted.

Several expensive devices developed during World War II are being utilized by wildlife biologists today. These devices involve the use of sonar and radar. It is not the intent of this paper to discuss automation in fisheries work although numerous techniques dealing with such areas as automatic chemical analysis, limnological sampling, and fish population sampling have been devised. The Russians now have ships which, by automation, navigate, search out fish, catch them, haul them in and process these fish in a continuous operation (Schaefer, 1963). Sonar is being used by commercial fishermen to locate schools of fish and by biologists to follow the movements of fish (Trefethen, 1956). A similar device, radar, is being utilized to study bird migration (Drury, Nisbet, and Richardson, 1961; Graber and Hassler, 1962). Perhaps metal discs imbedded in some of these migrating birds would help in the detection of individuals by returning stronger signals.

Electronic engineers have come a long way in developing means of detection through sight. Such equipment as the television and movie cameras could be utilized in the same way as other types of recording. However, some method of automatically recording the picture, identifying the picture, and tabulating the results would need to be developed. The cameras, of course, could be triggered by electric eye thus eliminating the use of excessive film. There are now automatic money changers that "recognize" the values of different denominations of paper money. Getting records at night would pose additional problems which could be solved by using infra-red film or infra-red light.

Perhaps the most promising sense which could be utilized and the one which has been largely neglected by biologists is the sense of heat which can be detected by the infra-red rays being emitted by the object. The use of infra-red film was mentioned earlier. The snooper scope was based on the principle of heat through detection of reflected infra-red rays (Seubert, 1948) and several biologists have watched animals using infra-red light (Southern, Watson, and Chitty, 1946). In this age, our space engineers have developed devices which can detect these rays at tremendous distances. The best example is the anti-missile missile which homes in on an approaching missile which is miles away (Spencer, 1960). Again, there is a tremendous amount of restricted information which, if released by the armed forces, could give us a significant forward push in our technology. All birds and mammals produce body heat. If we had heat (infra-red)-sensitive instruments, we could more accurately census many hard-to-census forms. If such instruments could be calibrated to specific amounts of infra-red radiation, perhaps various species could be indentified by specific patterns of emission (Anonymous, 1963). Again, such instruments could be constructed to detect, transmit, and record automatically at one place.

We need to explore the possible use of X-rays in field work. Portable equipment is now available and is being used by biologists (Verme, Fay, Mostosky, 1962). Pictures of animals inside the trunk of a tree could be taken, but limits on the handling of film and the distance of the machine from the object pose unanswered problems.

In addition, new rays are being developed (the laser ray,for example), and each needs to be examined for its potential.

The possible use of magnets placed on different animals has not been investigated. Such magnetic bodies could be recorded rather easily and inexpensively under the proper conditions.

Automation in game production needs to be appraised. As human populations increase in size and game habitats decrease in size, the chances of survival of each individual of every species are being decreased. Today, the ''put-and-take—pay-as-you-hunt'' system is becoming more popular. Such systems of hunting will become even more popular. As much as many of us, myself included, have talked against game farms, we may find ourselves returning to them. The problem many states will face in the near future is whether animals should be raised by the state for put-and-take shooting. This problem needs to be studied now together with more efficient systems of raising game. Modern systems of handling poultry and cattle should be examined with game species in mind. The rearing of all types of game animals in as wild a condition as possible should be explored. Perhaps automatic equipment, used to care for these animals with little human disturbance, will help preserve that characteristic of wildness which often is lost.

The problem of waterfowl production is being faced now by the Fish and Wildlife Service. Perhaps a modern approach to a technique as old as the Euston system, where recently laid eggs are replaced by artificially incubated eggs, should be attempted to increase numbers and success in waterfowl production on our dwindling marshes. New concepts need to be tried to increase production on the breeding grounds still available. We must increase the average clutch size of these ducks, even if we have to do it artificially, if we are to keep up with demand or even continue to be in business in future years.

In this paper, I have attempted to show that modernization through automation has started in various facets of our wildlife programs. Our viewpoint toward automation should be enthusiastic and constructive. Our administrators should be encouraged to support original but sound avenues of approach. Initial investments in automation may be expensive, but with the proper equipment it would be possible to obtain detailed information which would be prohibitive in terms of salaries, time, and personnel under our present systems of management. These fresh approaches for the most part will stem from our new crop of biologists entering the field. Our colleges then must lead the way in providing biologists well founded in the fields of chemistry and physics as well as in their major interest.

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DISCUSSION

FRANK BARRICK [North Carolina]: You have some mighty good ideas there. I would like to ask you if you or anyone else in the audience had given any thought to two ideas which occurred to me along the line which you have described. One has to do with the automatic recording, or the much more rapid recording of vegetation. In the field of light reflection where you have certain reactions to vegetation so that you could very rapidly drive through the woods and make recordings of the density of the vegetation in predetermined locations or random locations.

It seems to me if we could get someone to develop a machine like that, it would tremendously increase the speed with which we could record the amount of grouse and deer on a range.

Another idea in connection with deer management is in the area of predator control. We know in many places the predator, especially the stray dog, is a deterrent in increased deer herds. I have been kicking this around for some time and I was wondering perhaps if anyone in our association has developed anything along this line. This possibly might consist of some type of a live trap with perhaps a large pen. The idea being first of all to put a female dog to attract the male. I understand that you can get a hormone to inject into a female to keep them constantly in heat. Of course, going one step beyond that is the odor idea which we were talking about and perhaps a sound thing, mechanical dog and if it would give off this particular odor it might possibly attract the predator dog.

MR. STAINS: Let me try and answer both of those questions as best I can, which isn't going to be too good. First of all, on the problem of vegetation, it is true that different types of vegetation emit different types of infra-red rays. There has been some preliminary work done in the form of a master's thesis at Ohio State University in which they used the snooper-scope to study different types of radiations from different kinds of plant material. However, this is just a beginning study and I don't know whether anything further has been done on it or not.

Now, as far as the dog problem goes, this odor problem was basically attacked by the entomologists on cockroaches. What they were doing was attempting to attract by means of a sex odor in the cockroach. So, they were working along the same lines that you were speaking of in using odors to attract feral dogs.

REVEGETATION AND MANAGEMENT OF CRITICAL SITES FOR WILDLIFE[1]

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Surface mining or strip mining of coal and lignite with the accompanying development of spoil banks has affected approximately 760,000 acres of land in 25 states as of December, 1961. Of this total affected area, approximately 690,000 acres of spoil banks, commonly referred to as strip lands, are located in a contiguous group of states; namely, Illinois, Indiana, Kentucky, Ohio, Pennsylvania, Tennessee, and West Virginia (Sawyer, 1962; Schoewe, 1960).[2]

The amount of land disturbed by strip mining relative to the total land area in each of these aforementioned states ranges from approximately one one-hundreth to one-half of one per cent.

Because of variations in the removal and deposition of the overburden from above the coal seam, and the peculiar physical and chemical characteristics of the strata of the coal measures, critical site problems affecting the establishment of vegetation are present. In addition to the above influence on coal strip land site development, moderate to extreme compaction of the surface spoil may result due to the heavy machines used in grading spoil banks. Also, extreme topographic features and exposures occur. Collectively, these various influences result in the development of sites having one or more factors critical or detrimental to the establishment of vegetation. That problems do exist concerning revegetation and utilization of surface mined lands is indicated by the fact that prior to 1953 a total of 135 papers was published (Limstrom, 1953), and over 90 papers since that date (Funk, 1962). The majority of the papers are concerned with reclamation through the use of forest and forage species with little or no attention to the possibilities for wildlife habitat development and management. Trees and forage species represent about 60 and 40 per cent respectively on acreages of strip lands reclaimed in Ohio in recent years (Ohio Division of Reclamation, 1960). These percentage figures correlate very closely with the ratio of acid spoil to neutral or alkaline spoil acreage.

The objectives of this study were: (1) to field test and evaluate the adaptability of various plant species having possible value to wildlife on sites varying in acidity and toxicity; (2) to develop wildlife

[1]Financial support for the project was provided by Kent State University, the Ohio Reclamation Association, and the Wildlife Management Institute.

[2]Additional data pertaining to land affected by surface mining for coal and lignite were obtained through correspondence with state geological agencies.

management techniques applicable to sites on coal strip lands; and (3) to apply these methods both during initial reclamation of the strip lands and to older established plant communities.

The data presented in this paper resulted from studies conducted during the period 1951-1962. Eighty-five species of trees, shrubs, grasses, and legumes[3] were planted or seeded on 107 plots throughout eastern and southeastern Ohio. Five native species and 18 exotic species (ornamentals) were included in this group.

Soil studies, including analyses, chemical changes and leaching of the surface spoil, and rates of water infiltration have been continued since 1957.

METHODS

Tree and shrub seedlings were planted by hand usually during March, April, and May. Seedings were usually made when the spoil surface was "honey-combed" during February and March.

Plots ranged in size from one-tenth to two acres. Critical site factors, including acidity, alkalinity, soil texture, moisture, topography, and the presence of toxic materials, were considered in the selection of spoil plot locations. Spoil material varied from 1 to 12 years of age when planted, although nine plots were established following the grading of old spoil banks which were developed in 1918, 1935, and 1942. In grading the old spoil banks, as much as 12 feet of spoil was removed and the material deposited in ravines and depressions.

Plantings were surveyed during July and August to determine survival, growth rates, growth characteristics, vigor, seed and fruit production, utility for wildlife, and erosion control. Three-foot wide belt transects were established within seedings, and the percentage of the spoil surface covered by the plant species was estimated.

Composite soil samples collected from various spoil types were analyzed.[4] Each composite sample was drawn from a mixture of 15 subsamples which had been collected from approximately a one-acre sampling volume. Procedures followed were those outlined by Jackson, 1958.

The effects of surface spoil compaction on water infiltration,[5] plant survival, and growth were also measured using the method devised by Baver (1947).

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[3]Planting stock and seed were provided by the U. S. Soil Conservation Service, U. S. Dept. of Agr., and the Ohio Reclamation Association.

[4]Soil samples were analyzed by the Jackson B. Hester Agricultural Research Laboratories, Route 4, Elkton, Maryland.

[5]Rates of water infiltration were measured in compacted and non-compacted spoil by forcing a 6-inch diameter metal cylinder to a depth of 2 inches below the surface. The infiltration time required for a known amount of water was recorded.

Experimental wildlife management techniques and practices were established during the initial reclamation phase as well as in established forest and forage communities.

CHARACTERISTICS OF STRIP LAND SITES

During surface mining operations, the strata or overburden materials overlying the coal seam are removed and deposited as a heterogeneous, disorganized mass, referred to as spoil. This raw spoil was deposited as sedimentary materials up to 120 feet in thickness some 250 million years ago. The resulting root medium or seed bed contrasts sharply to the physical and chemical nature of normal soils which have evolved by more orderly processes.

Earth strata, which compose spoil or the surface layer of strip lands, hereafter referred to as soil, have been described by Chapman (1944) and by Limstrom (1948, 1960). Strip land soils may vary in particle size from the usual clays and silts to massive limestones and sandstones weighing several hundred pounds. Adjacent to these large rocks, extremes in soil conditions may result because of the slow process of weathering and the continuous release of chemicals. Pyritic materials such as marcasite and iron pyrite (FeS_2) occur as crystals throughout much of the shale and sandstone or as fairly large concretions immediately above or within the coal seam. Upon exposure to air these materials release acids which may create toxic conditions for plants. Chemicals released consist almost entirely of mixed sulfate salts, originating as iron sulfate and sulfuric acid and produced by the oxidation of pyritic minerals. Additional reactions with adjacent fragmented rock bring into solution metallic elements such as calcium, magnesium, aluminum, manganese, sodium, and potassium. Calcareous rocks and spoil material will yield neutral sulfates of calcium, and magnesium, while acidic rocks and spoils yield acid sulfates of aluminum, iron, manganese, and other ions (Struthers, 1961).

The analyses of the soils in which plantings and seedings were established are summarized in Table 1. While the minimum and maximum conditions are extreme in some instances, the median and average data provide a more reliable basis for judging the success of vegetation. For comparison of soil conditions between strip lands and the undisturbed soils of the same region, note the analyses results of four samples of the latter in Table 2.

Under field conditions it is difficult to determine at which concentration any one of the specific elements is limiting or critical to a plant species. The tests, of the spoil material, indicate a range in pH values from 2.7 to 8.2. Wilde (1954) points out that the pH or soil

TABLE 1. SOIL CONDITIONS ON COAL STRIP LAND[1]

	Minimum	*Maximum*	*Median*	*Average*
pH	2.70	8.20	4.35	5.02
O.M. %	0 80	8.90	1.80	2.11
MAJOR PLANT FOODS – lbs./acre				
Nitrate NO_3	T[2]	22 00	1.00	2.32
Ammonia NH_3	2.00	70.00	30.00	31.48
Phosphate P_2O_5	0.20	40.00	2.10	5.35
Potash K_2O	4.00	323.00	71.00	79.05
Calcium Ca	12.00	22.250 00	1205.00	3067 24
Magnesium Mg	0.60	440 00	158.00	162.22
TRACE ELEMENTS – lbs./acre				
Iron Fe^{+++}	T	72.52	0.40	2.29
Manganese Mn^{++}	0.13	47 80	9.56	13.37
Boron B^{+++}	0.12	0.44	0.31	0.30
Copper Cu^{++}	0.75	50.00	12.35	15.03
Zinc Zn^{++}	T	33.40	12.50	13.47
Molybdenum (pp_2b)[3]	10.00	1000.00	100.00	125.64
TOXIC CONDITIONS – lbs./acre				
Sulfate "S" as SO_4	10.00	626.00	215.50	196.54
Chloride Cl	0.80	64.00	4.35	6.55
Aluminum Al	0 00	43.00	1.48	4.61
Total Soluble Salts	40.00	9000.00	1270.00	1782.20

1 Results of 78 composite soil samples analyzed.

2 (T) – Trace–less than 0.1.

3 (pp_2b) – parts per 2 billion.

reaction exerts a definite influence on the life functions of organisms, availability of plant nutrients, and physical properties of soils. He also states that profound adverse effects of hydrogen or hydroxyl ions *per se* are revealed only at the extremes of acidity (pH 3.0) and alkalinity (pH 9.0). An additional effect of a low soil pH is the fixation of some insoluble nutrients. The analyses indicated a deficiency in 97 per cent of the tests for nitrate nitrogen, in 76 per cent of the tests for ammonia nitrogen, in 80 per cent of the tests for phosphorus, and in 72 per cent of the tests for potash. Approximately 50 per cent of the analyses were low in calcium and 48 per cent in magnesium. The main effects of soil nutrients in promoting plant survival and growth are associated with the acidity and physical charac-

TABLE 2. SOIL CONDITIONS ON UNDISTURBED LAND[1]

	Minimum	*Maximum*
pH	5.00	7.00
O.M. %	1.10	1.50
MAJOR PLANT FOODS – lbs./acre		
Nitrate NO_3	1.30	4.70
Ammonia NH_3	5.00	11.00
Phosphate P_2O_5	0.50	1.10
Potash K_2O	44.00	65.00
Calcium Ca	477.00	1585.00
Magnesium Mg	48.00	118.00
TRACE ELEMENTS – lbs./acre		
Iron Fe^{+++}	0.30	0.40
Manganese Mn^{++}	0.13	2.21
Boron B^{+++}	0.26	0.31
Copper Cu^{++}	1.60	4.80
Zinc Zn^{++}	2.90	4.30
Molybdenum (pp_2b)	10.00	50.00
TOXIC CONDITIONS – lbs./acre		
Sulfate "S" as SO_4	20.00	46.00
Chloride Cl	16.00	34.00
Aluminum Al	0.06	0.30
Total Soluble Salts	180.00	240.00

1 Results of four composite soil samples analyzed.

teristics of soil. For this reason it is not advisable to evaluate nutrient availability *per se* in the general classification of strip-mined land for revegetation (Limstrom, 1960).

Substances known to be toxic or at least limiting to plants, if present in sufficient concentrations, include soluble salts of iron, manganese, aluminum, copper, and sulfates. The concentration at which these substances become limiting or toxic vary with soil moisture, texture, and the plant species involved. For example, Jackson (1958) indicates that the toxic limit percentage for soil salts for a peat bog soil is 0.35 per cent, for a silt loam is 0.1 per cent, and 0.05 per cent for a coarse loamy sand. The 0.1 per cent salt limit is approximately equivalent to 2,000 pounds per acre. For more tolerant species this value is doubled. Approximately 30 per cent of the soil samples analyzed contained 2,000 pounds or more of salts per acre.

TABLE 3. EVALUATION OF TREES

Species	Soil Factors lbs. per acre				Growth Results				
	Spoil Type[1]	pH	Sulfur As Sulfates (SO_4)	Total Soluble Salts	Age (Years)[2]	Survival (Per Cent)[3]	Height (Range)[4]	Foliage Diameter (Range)	Vigor[5]
Black Locust									
Robina Pseudo-Acacia	A	3.4	270	4100	4	97	8' / 16'	7' / 10'	G
European Alder									
Alnus glutinosa	C	6.1	82	600	4	98	4' / 10'	2' / 4'	G
Tall Purple Willow	C	6.6	299	4400	4	95	4'-6'	6'-9'	E
Salix purpurea lambertiana	S	5.4	292	2980	1	79	10"-41"	–	G
Medium Purple Willow	C	6.6	299	4400	4	95	3'-5'	2'-6'	E
Salix purpurea gracillis	S	5.4	292	2980	1	74	12"-18"	–	G
Manchurian Crab Apple									
Malus baccata mandshurica	C	6.6	292	4400	4	100	34" / 53"	2' / 3'	E
American Crab Apple									
Malus sp.	C	6.6	292	4400	4	100	15" / 36"	10" / 24"	F
Wild Black Cherry									
Prunus serotina	A	4.1	184	800	8	45	8' / 12'	–	F
Norway Spruce									
Picea abies	S	6.0	292	3200	3	90	8" / 14"	–	G
White Pine									
Pinus strobus	A	4.1	184	800	10	97	6' / 17'	3' / 8'	E
Scotch Pine									
Pinus sylvestris	A	4.1	184	800	8	93	3' / 8'	3' / 6'	G

FOOTNOTES APPLY TO TABLES 3, 4, 5, and 6.

1. A – Acid and toxic silty shale spoils.
   C – Calcareous and acid clays, shale and limestone.
   S – Acid and toxic sandstone, and occasional calcareous shale.
2. Indicates age when planting or seeding was evaluated for data reported.
3. Indicates per cent of survival for planted species and per cent of spoil surface covered for seeded species.
4. Indicates vertical growth for upright species and horizontal growth for vines.
5. E – Excellent. G – Good. F – Fair.

Soil texture, water relations, and salt composition probably extend these limits to a much higher value, except in soils of extreme acidity.

Salt absorption by plants is affected by environmental factors such as temperature, light, carbon dioxide, hydrogen ion concentration, and interaction between ions. Plants possessing structural characteristics such as shallow root systems and a large shoot-to-root ratio exhibit poor water absorptive capacity in relation to transpiration. They also exhibit a low salt tolerance. In contrast, relatively slow growing plants having a low shoot-to-root ratio tend to be more salt tolerant (Sutcliffe, 1962).

The success of grass and legume seedings was definitely affected by surface compaction. The rate of water infiltration for non-compacted surface spoil versus compacted surfaces on silty shale, clay, and sandstone spoils was from 49 to 89 per cent more rapid.

DISCUSSION

Evaluation of Plant Species

While a total of 85 species of plants was originally planted or seeded, only 57 species are included in this report. Twenty-eight species either failed completely or were not considered successful. Those considered successful were rated on the basis of survival, percent of spoil surface covered, and vigor in relation to the specific soil conditions. Vigor included foliage color, annual growth, bark condition, and presence of disease or insect damage. For each species vigor was rated as fair, good, or excellent. Additional characteristics used in rating the various species were fruit and seed production, retention of fruit and seeds, foliage diameter of individual plants, height, ability to withstand heavy snow, and reproduction. In evaluating each species these characteristics were considered from the standpoint of food and cover for wildlife.

Included in the 57 species rated as successful are 10 species of trees (Table 3), 16 species of grasses (Table 4), 16 species of legumes (Table 5), and 15 species of shrubs and vines (Table 6). The pH of the spoil material ranged from 3.4 to 7.2, and in all but four of the plots, acid to extremely acid soil conditions existed. The soluble salts in most instances were those of acid sulfates of aluminum, copper, iron, manganese, zinc, and other ions. Many of the species, especially the legumes and grasses, exhibited a greater tolerance to low pH than reported by Jackson (1958). Alfalfa, sweetclover, Kentucky blue grass, orchard grass, red top, timothy, and river grape grew quite successfully below the minima of pH indicated by this author. The same author also indicated that for a fertile silt loam soil, 1500 ppm (3,000 pounds per acre) in the soil is often found to be the maximum salt content for growth of soft-stemmed plants, and 2500 ppm (5,000 pounds per acre) in the soil for growth of

TABLE 4. EVALUATION OF GRASSES

Species	Soil Factors lbs. per acre				Growth Results			
	Spoil Type[1]	pH	Sulfur As Sulfates (SO_4)	Total Soluble Salts	Age (Years)[2]	Surface Covered (Percent)[3]	Height (Range)[4]	Vigor[5]
Milo Sorghum *Sorghum subglabrescens*	S	4.5	260	3200	1	100	24"–30"	E
Blackwell Switch Grass *Panicum virgatum*	C	6.6	299	4400	4	96	10"–30"	E
Orchard Grass	A	4.0	232	720	6	100	12"–28"	E
Dactylis glomerata	C	6.4	238	4400	4	100		
Sand Love Grass *Eragrostis trichodes*	S	7.2	190	600	2	100	6"–8"	F
Reed Canary Grass *Phalaris arundinacea*	S	4.5	260	3200	8	100	30"–38"	E
Tall Oat Grass *Arrhenatherum elatius*	S	7.2	190	600	2	100	8"–24"	G
Canadian Wildrye *Elymus Canadensis*	S	7.2	190	600	2	100	18"–32"	E
Red Top *Agrostis alba*	A	4.0	232	720	6	50	10"–20"	F
Kentucky Blue Grass *Poa pratensis*	C	6.1	82	600	10	100	8"–10"	E
Smooth Broome Grass *Bromus inermis*	C	6.1	82	600	5	100	10"–28"	E
Red Fescue *Festuca rubra*	C	6.6	299	4400	4	60	6"–12"	F
Crested Wheat Grass *Agropyron sp.*	A	4.0	232	720	6	15	12"–26"	F
Timothy *Phleum pratensis*	A	4.1	184	800	2	40	10"–24"	F
Jap Millet *Echinochloa frumentacea*	A	4.0	219	5800	1	–	24"–30"	G
Broomsedge *Andropogon virginicus*	A	4.0	184	800	15	50	18"–28"	G
Weeping Love Grass *Eragrostis sp.*	A	4.0	232	720	6	10	10"–12"	F

TABLE 5. EVALUATION OF LEGUMES (SHRUB AND HERBACEOUS TYPES)

Species	Soil Factors lbs. per acre				Growth Results					
	Spoil Type[1]	pH	Sulfur As Sulfates (SO_4)	Total Soluble Salts	Age (Years)[2]	Survival (Per cent)[3]	No. Stems Per Plant	Height (Range)[4]	Foliage Diameter (Range)	Vigor[5]
Shrub Lespedeza	A	4.8	226	2500	13	95	2/15	5'/9'	2'/5'	
Lespedeza bicolor	A	4.0	219	5800	4	90				E
Cyrtobotrya Lespedeza	A	4.8	226	2500			5/8	4'/5'	2'/3'	
L. cyrtobotrya	A	4.0	219	5800	13	20				G
Thunberg Lespedeza	A	4.8	226	2500			2/9	3'/5'	2'/3'	
L. thunbergi	A	4.0	219	5800	13	15				G
Natob Lespedeza							5/10	3'/8'	2'/4'	
L. bicolor natob	A	5.7	280	3600	4	100				F
Japan Lespedeza	S	4.5	260	3500	10	95	6-12	4'-7'	3'-4'	
L. japonica	C	6.6	299	4400	4	98	13-18	2'-6'	3'-4'	E
Sericia Lespedeza	A	4.8	226	2500	13	60	–	36"/40"	–	G
L. cuneata	C	6.1	82	600	10	100	–		–	E
Rush Lespedeza								27"/34"		
L. hedysaroides	C	6.6	299	4400	4	100	–		–	G
Daurica Lespedeza								6"/12"		
L. daurica schmidae	S	7.2	190	600	2	100	–		–	G
Sweetclover								30"/48"		
Melilotus officinalis	A	4.0	219	5800	8	85	–		–	E
Scotch Broom	A	4.1	184	800	3	70	7/10	2'/4'	30"/55"	
Cytisus scoparius	A	4.8	226	2500	3	85				E
Common Woadwaxen							50/60	24"/28"	3'/5'	G
Genista tinctoria	C	6.6	299	4400	3	60				G
Crown Vetch	C	6.1	82	600	6	100	–	24"-30"		E
Coronilla varia	A	4.0	232	720	6	100	–	12"-28"	–	G
Perennial Sweet Pea								24"/28"		
Lathyrus latifolius	C	6.6	299	4400	4	100	–		–	E
Showy Partridge Pea								12"/16"		
Chamaecrista fasciculata	C	6.6	299	4400	3	60	–		–	G
Birdsfoot Trefoil								6"/8"		
Lotus corniculatus	A	4.0	232	720	6	70	–		–	F
Alfalfa								16"/20"		
Medicago sativa	A	4.0	232	720	6	100	–		–	G

TABLE 6. EVALUATION OF SHRUBS AND VINES

Species	Soil Factors lbs. per acre				Growth Results					
	Spoil Type[1]	pH	Sulfur As Sulfates (SO_4)	Total Soluble Salts	Age (Years)[2]	Survival (Per cent)[3]	No. Stems Per Plant	Height (Range)[4]	Foliage Diameter (Range)	Vigor[5]
Hazel Nut *Corylus americana*	A	5.7	280	3600	4	100	7/14	14"/42"	24"/28"	E
Amur Honeysuckle *Lonicera maacki podocarpa*	C	6.6	299	4400	4	97	3/6	24"/63"	12"/60"	E
Tartarian Honeysuckle *L. tatarica*	A	4.1	184	800	4	60	4/8	5'/7'	20"/36"	E
Jap Honeysuckle *L. japonica*	A	4.0	219	5800	10	–	–	15'	–	G
Autumn Olive *Elaeagnus umbellata*	S	5.2	299	3200	4	60	3/7	34"/61"	17"/44"	G
Autumn Olive *E. umbellata*	A	4.1	184	800	5	72	3/10	3'/10'	3'/9'	E
Indigobush *Amorpha fruiticosa*	A	4.8	226	2500	13	90	1	6'/10'	3'/6'	E
Ninebark *Physocarpus opulifolius*	C	6.6	299	4400	4	80	7/11	12"/38"	20"/24"	G
Western Sandcherry *Prunus besseyi*	S	5.4	292	2980	1	82	1	10"/24"	–	G
Memorial Rose *Rosa wichuriana*	S	5.2	299	3200	4	60	6/14	5'/13'	–	G
Multiflora Rose *Rosa multiflora*	C	6.1	82	600	10	98	3/14	6'/8'	6'/10'	E
River Grape *Vitis sp.*	A	5.7	280	3600	4	70	–	6'/20'	–	E
Bittersweet *Celastrus scandens*	A	4.0	219	5800	10	–	–	6'/8'	–	G
Pokeberry *Phytolacca decandra*	A	4.1	184	800	4	–	5/8	3'/6'	4'/6'	E
Greenbrier *Smilax glauca*	A	3.5	178	560	3	–	–	2'/4'	–	F

woody plants. Many of the legumes and grasses were successful beyond these limits.

Tolerance to high concentrations of trace elements was exhibited by several species of trees, crown vetch, alfalfa, birdsfoot trefoil, orchard grass, and weeping love grass. These species were successful on spoil having a pH of 4.0 and containing 0.3 pounds of iron, 24.0 pounds of manganese, 23.1 pounds of copper, 14.0 pounds of zinc, and 4.09 pounds of aluminum per acre. Black locust, white pine, bicolor lespedeza, scotch broom, and multiflora rose grew in spoil with a pH of 3.4 and 8.1 pounds of iron, 47.8 pounds of manganese, 41.6 pounds of copper, 22.5 pounds of zinc, and 1.4 pounds of aluminum per acre. European alder, autumn olive, tall and medium purple willow, and western sand cherry failed at a pH of 3.5 and 72.5 pounds of iron, 18.5 pounds of manganese, 24.5 pounds of copper, 12.5 pounds of zinc, and 28.0 pounds of aluminum per acre. These same species growing on adjacent spoil with a pH of 5.4 and 0.3 pounds of iron, 24.0 pounds of manganese, 45.8 pounds of copper, 2.5 pounds of zinc, and 8.6 pounds of aluminum per acre had a survival of 95 per cent.

Growth and survival of shrubs, grasses, and legumes were adversely affected by spoil compaction. On compacted soil, orchard grass at two years averaged 7 inches in height and covered 80 per cent of the surface, while on adjacent non-compacted spoil the same species averaged 11 inches in height and covered 100 per cent of the surface. Similar effects were present with respect to bicolor lespedeza, Japan lespedeza, Sericea lespedeza, and birdsfoot trefoil. When seedlings were used, there was little effect on survival although growth in height was reduced.

MANAGEMENT OF COAL STRIP LAND FOR WILDLIFE

Because of the relatively large acreages to be reclaimed annually (8,000-10,000 acres in Ohio) and the objectives of the landowners for the future use of coal strip lands, forestry and grazing will continue as the major programs. There are many opportunities, however, to modify present coal strip land reclamation practices and programs, and thus create habitat conditions which are more conducive to the production of wildlife. There are undoubtedly more opportunities to establish transition zones or ecotones on reclaimed coal strip lands or on those about to be reclaimed than on lands under conventional agriculture and other uses. Ecological principles and wildlife management methods or practices should be applied during the initial reclamation phase.

Improvements in already existing forest plantings, some of which date back to the early 1920's, include the development of grass-legume strips through the planting. Older forest areas quite often consist of hardwoods with a high percentage of black locust, often in a decadent condition. Such strips, created by a bulldozer, should have a minimum width of not less than 50 feet and a maximum of

100 feet. On strips less than 50 feet in width, black locust usually invades and closes the area within five years even though spoil has been removed to a depth of 12 feet by grading. Abundant locust roots were found at the 10- and 12- foot depth, many of which produced new shoots. If extensive management is practiced, it is not economically feasible to attempt chemical control of black locust. Strips created through plantations of hardwoods, other than black locust, have remained open for six years with practically no invasion by tree species. The invasion of grass-legume strips is, however, influenced by the percentage of the spoil surface covered by vegetation.

In large seedings of grasses and legumes, some of which cover 100 acres or more, a similar strip of not over 20 feet in width can be created and planted to Sericea, shrub or bush lespedeza, scotch broom, autumn olive, woadwaxen, and multiflora rose. These same plants along with selected tree species may be used on the perimeter slopes of strip lands or in old fields adjacent to the stripped unit. The shrub species listed above, plus memorial rose, crown vetch, conifers, or tall and medium purple willow, can be planted within or or at the edge of large depressions or rock dumps, which are areas that have not been filled during the process of grading. Crown vetch grows very profusely on neutral to calcereous spoils and creates extremely moist or wet conditions near the spoil surface. However, on acid spoil where crown vetch grows less profusely, excellent cover results.

Mowing strips 30 to 40 feet in width through seedings of smooth brome grass, orchard grass, Sericea lespedeza, and sweetclover, not only enhances the habitat for wildlife but also makes the area more accessible for hunting. If such strips are mowed during September and early October, the resulting new growth provides more palatable food for certain species.

While these management techniques can be used to enhance previously reclaimed areas, they should be programmed and put into effect when the initial reclamation work is being done.

Habitat can also be improved by modifying the present concept of spacing in establishing forest plantations. While there are many sound reasons offered for the present spacing of 7 feet by 7 feet, there are indications that the first generation of trees on strip lands will produce little income from commercial forest products. In a few experimental forest plantings, the spacing was increased to 14 feet and the surface spoil seeded to grasses and legumes. As a result of the increased spacing, the canopy remained open for a much longer period of time and the unit was far more valuable to wildlife.

A similar approach has been to plant strips of normally spaced trees with intervening strips of grasses and legumes. At the juncture of the tree and grass-legume strip, conifers or close growing shrubs should be planted to provide the desirable edge effect.

Surface mining in regions having extremely steep topography may result in a long narrow strip of spoil material. On such areas a grass-legume seeding or planting of shrubs should be made. Eventually a forest community will develop; but during the interim period, wildlife will have benefited.

The practice or method employed, the planting plan, spacing, amount of seed per acre, and species used must be determined by a competent wildlife biologist. He must, of necessity, consider the viewpoint and desires of the landowner, the use for which the strip land unit is best suited as well as what plant species will be successful on the specific spoil material.

SUMMARY

Surface mining for coal had affected approximately 690,000 acres of land in Illinois, Indiana, Kentucky, Ohio, Pennsylvania, Tennessee, and West Virginia as of December, 1961. The strip lands, after mining operations are completed, are generally reclaimed for forestry or grazing. By modifying present reclamation concepts and by instituting basic wildlife management principles and practices, the reclaimed strip lands can be made more productive for wildlife.

Data resulting from the analyses of 78 composite soil samples, which were collected from experimental strip land plots in Ohio, indicated the presence of certain factors which could be toxic or limiting to plant survival and growth. Soil reaction, an important factor for the spoils sampled in this study was extremely acid to slightly alkaline. The pH values for spoil in which various plant species were field tested ranged from 2.7 to 8.2. Sulfates (SO_4) ranged from 10 to 626 pounds and total soluble salts 40 to 9,000 pounds per acre. Relatively high concentrations of aluminum, copper, iron, manganese, molybdenum, and zinc were present in some samples. Deficiencies of nitrogen, phosphorus, and potash were indicated although approximately 50 per cent of the spoil tests revealed adequate amounts of calcium and magnesium.

Compaction of the surface soil decreased the rate of water infiltration on certain spoil types and adversely affected the establishment of vegetation by seeding.

A total of 85 plant species were field tested on 107 strip land plots in southeastern Ohio. Plots were located on selected spoil types having critical site factors such as extreme acidity, high total salts, and compacted surface spoil. Of the various trees, shrubs,

grasses, and legumes tested under field conditions, 57 species were rated as being successful on the specific soil conditions cited in tables three, four, five, and six of the text. The successful plant species grew on soil having a range of pH values from 3.4 to 7.2; all but four of the plots exhibited acid to extremely acid soil reaction. Many species of shrubs, grasses, and legumes diplayed a tolerance to very acid soils, high concentrations of trace elements, sulfates, and soluble salts.

Management techniques that appeared to be both economically feasible and practical for enhancing the habitat for wildlife included the development of strips of vegetation, thus creating more edge or border effect. Strips and openings were created in established forest plantations and pasture seedings by the use of the bulldozer. The areas within the forest communities were seeded to grasses and legumes such as Sericea lespedeza, crown vetch, birdsfoot trefoil, alfalfa, timothy, orchard and smooth brome grass while the shrubby species such as bicolor Sericea and Japan lespedeza were used to produce strips within the pasture lands. Additional techniques included increasing the normal tree spacing standards to 14 feet and seeding the spoil surface to grasses and legumes. Trees, normally spaced, were also planted in narrow strips with seedings of grasses and legumes located between the tree strips. Mowing lanes within established pastures, in late summer and autumn, resulted in the production of more palatable vegetation as well as more satisfactory conditions for hunting.

ACKNOWLEDGMENT

The author wishes to express his appreciation to Mr. Larry Cook, Executive Vice President, Ohio Reclamation Association for making available field crews for establishing the experimental plantings and seedings. Acknowledgement is also due Mr. William Briggs, Plant Materials Technician, U. S. Soil Conservation Service, Dr. Paul Struthers, Assistant Professor, Department of Agronomy, Ohio Agricultural Experiment Station for invaluable assistance in the selection of plant species and interpretation of soil data, and to the many landowners who cooperated in the establishment of the experimental plots.

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DISCUSSION LEADER SANDFORT: I was wondering if the practices were being accepted by the land owners or the farmers and to what extent these practices are being defied.

DR. RILEY: The answer would have to be somewhat mixed. If we compare what we are able to do today in the way of applying wildlife management practices on the strip lands in Ohio, with what we got across to state authorities and to the landowners and operators back ten or twelve years ago, we have a one-hundred percent gain. In the last two or three years the change in attitude on the part of both the state and the operators has been tremendous.

For example, this year we are putting in about 300 acres, which is a small amount of eight or nine thousand which will be reclaimed. However, this will be about 300 acres put in strictly for wildlife management techniques, which is a tremendous gain.

MR. SANDFORT: Because the pH levels are extremely low these are extremely acid soils, and I presume it would take truckloads of commercial fertilization to neutralize the earth. Has there been any attempt to utilize commercial fertilization?

MR. RILEY: There has been some work done, but I can't give you the results. However, actually the soil acidity is not quite as important as far as growth of plants is concerned as we were led to believe.

Wilde, in a study made a few years ago on the facts and fallacies of soil reaction, points out that soil reaction *per se* does not affect plant growth or survival of any land organisms until it gets down around pH 3. or gets up around pH 9. This is as long as the plant nutrients are available. It does have an effect on the physical structure of the soil and also the solubility of certain nutrients.

MR. STAINS: Are other States going into this depressed area renovation program that the Government is supporting which we are trying to use in Southern Illinois? It is possible that this strip land could be developed for recreation under the Depressed Areas Bill.

RHYTHMIC FLUCTUATIONS IN SOUTH DAKOTA PHEASANT POPULATIONS AND ASSOCIATED ADULT MORTALITY, 1947-62

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This paper presents a partial analysis of population data obtained from pheasant research studies in South Dakota during the past 16 years. Principally considered are (1) population fluctuations with their apparent periodicity, (2) population change in South Dakota compared with trends in other states, and (3) the annually varying mortality of adults.

This study has resulted from Federal Aid in Wildlife Restoration Projects 17-R, 74-R, and 75-R. The work of many past and present game personnel in South Dakota, whose quarterly progress and job completion reports the author has used freely, is gratefully acknowledged. Wind data for past years were supplied through the kind cooperation of Walter Spuhler, U. S. Weather Bureau State Climatologist at Brookings, South Dakota, and William T. Hodge, National Weather Records Center, Asheville, North Carolina.

POPULATION TRENDS

In order to adequately analyze a series of population trends, one must have some reliable yardstick of population size against which to measure other factors. Frequently, those who manage pheasant populations are perplexed by numerous indices such as roadside counts, brood size, per cent of hens with young, young per hen, kill estimates, sex ratios, age ratios—when one index would seem to indicate a downward population trend and another index would seem to indicate an upward trend. These problems in assessing the status of the pheasant population in South Dakota led to the use of a pre-hunt (P_1) estimate formula presented by Hickey (1955), similar to that used by Allen (1942) and Kelker (1940). The use of the formula is as follows:

$$P_1 = \frac{f_2 K_T - K_f}{f_2 - f_1},$$

where f_2 is the decimal proportion of females following the season, from winter sex ratio counts; f_1 is the decimal proportion of females preceding the season, from summer rural mail carrier surveys; K_T is K_c plus K_f; K_c is the total cock calculated from mail survey plus 15 per cent as an estimate of crippling kill; and K_f is K_c times 25 per cent as an estimate of hen kill.

In using this formula in the past the author (1959, 1961) used the winter sex ratio and added the age ratio from the bag check in the fall to derive f_1. Age ratios have been seen to be unreliable and their use in this formula is therefore questionable. The following example illustrates how varying cock mortality during the summer will bias the age ratio adjusted for winter sex ratio:

Assume Winter Sex Ratio of 50:100	Young Cocks At Hunt	Age Ratio In Bag	Adjusted Ratio (young per hen)
50 (no mortality)	200	4.00	4.00
30 (loss of 20)	200	6.67	6.67
10 (loss of 40)	200	20.00	20.00

For this paper, pre-season sex ratios (f_1) have been determined from the summer rural mail carrier survey (RMCS). These ratios appear to be within reason, account for adult mortality through July of each year, and avoid the bias of adult mortality through age-ratio correction. The resultant curve of population trends (Figure 1) is similar in basic aspect to that reported earlier, but is generally lower in level of population estimate.

Corrections in basic data were made in summer RMCS figures for 1947, 48, 49, 52, and 55 since the surveys in these years were conducted one week too early. At this time of year, late July and early August, sex ratios are changing from week to week and numbers of birds observable are increasing. Numbers of birds seen on compar-

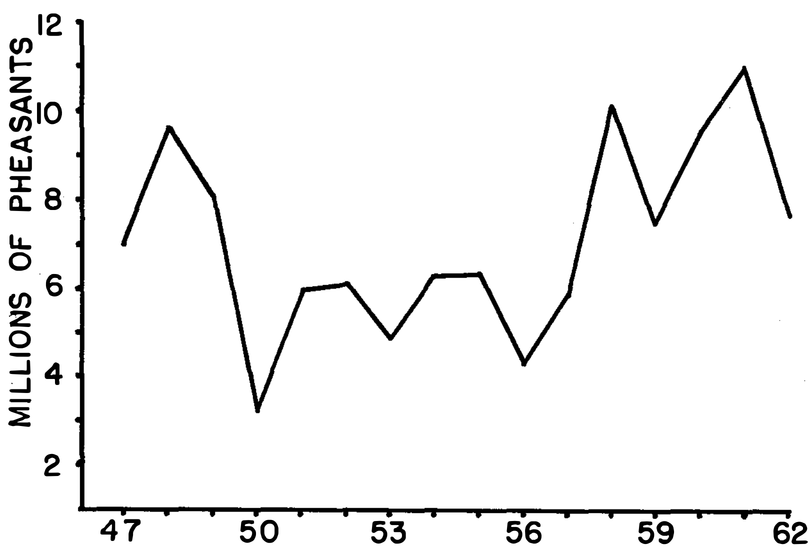

Fig. 1. Pre-hunt pheasant population estimates in millions for South Dakota, 1947-62.

able brood routes in 1952 and 1955 as shown (per 10 miles) were used as the basis of corrections:

	Cocks	Hens	Young
July 25-31	0.36	0.73	3.14
August 1-7	0.39	0.86	4.32
Per Cent Change	+8.3	+17.8	+37.6

In addition, the 1962 P_1 has been estimated on the basis of other surveys at 7.70 million to permit its use in calculations.

Correlation of P_1 With Other Indices

The pre-hunt estimate in millions coincides with expected trends as seen in the results of other surveys. Hunter success trends have been in accord with the P_1 estimate in every year when the bag limit has remained the same, suggesting that hunting success is mainly dependent on numbers of birds available to the hunter. The summer RMCS has yielded indices comparable to P_1 in trend for every year except 1949. Brood count routes, though not specifically designed for bird-per-mile results, have shown the same trend as P_1 since they were initiated in 1950. All of the evidence that we have points to the validity of the P_1 estimate for showing population trends (See Dahlgren, 1959).

Population Fluctuation Rhythm

A striking characteristic of the P_1 curve (Figure 1) is the periodicity of the "low" years, which occurs every three years, in 1947, 50, 53, 56, 59, and 62. Each of these lows is followed by two "better" years. Since 1959, when this periodicity was first noted, the author has forecast the exact trend in population based upon the periodicity noted in past data.

Whether these rhythmic changes are truly cycles or rather random fluctuations, as postulated by Cole (1951), is not known. It is to be hoped that these fluctuations will continue in a predictable fashion, as this would be helpful to game managers in anticipating the season-setting process and to researchers working on causative factors. The precise regularity of trend exhibited in the past would seem to be good grounds for predicting "good" pheasant years in 1963 and 64, and a "poor" pheasant year in 1965.

Trends in Other Midwest States[1]

If there are causative factors for these trends, one would expect their influence to extend over a large area. From 1955 on, when data

[1]Personal communications containing pheasant data which allowed P_1 calculations and other comparisons were kindly supplied by the following: Ken Johnson and John P. Weigand, Nebraska; Richard C. Nomsen, Iowa; R. Kahler Martinson, North Dakota; Paul E. Bremer, Minnesota; Robert Chambers, Ohio; Robert D. Feldt, Indiana; J. M. Gates and C. D. Besadny, Wisconsin; William L. Preno, Illinois; Robert D. Wood, Kansas; and V. S. Janson, Michigan.

TABLE 1. STATEWIDE KILL ESTIMATES FOR STATES IN THE MIDWEST PHEASANT RANGE EXPRESSED AS MILLIONS, 1947-61

Year	South Dakota	North Dakota	Minnesota	Wisconsin	Michigan	Indiana	Nebraska	Illinois	Kansas	Ohio
1947	1.496	0.280	None	0.295	0.453	None				
1948	2.148	0.460	0.668	0.299	0.633	0.037				
1949	1.865	0.410	1.128	0.384	0.864	0.038				
1950	0.507	0.060	0.891	0.414	0.798	0.041				
1951	1.184	0.193	0.929	0.466	0.944	0.040				
1952	1.490	0.175	1.072	0.487	0.897	0.041				
1953	1.210	None	0.593	0.522	1.247	0.044				
1954	1.672	0.200	0.659	0.505	1.106	0.058				
1955	1.608	0.235	1.090	0.564	1.183	0.074	0.480			
1956	1.221	0.325	1.043	0.522	1.126	0.081	0.369	0.712		
1957	1.339	0.286	0.776	0.552	1.258	0.085	0.527	0.680	0.152	
1958	2.635	0.525	1.562	0.472	1.181	0.113	1.149	0.911	0.563	0.200
1959	2.212	0.134	0.890	0.278	0.915	0.113	1.220	0.762	0.704	0.186
1960	2.572	0.240	1.164	0.274	0.974	0.110	1.165	0.712	....	0.166
1961	3.247	....	1.305	0.346	0.846	0.116	1.298	0.852	0.700	0.144

TABLE 2. SUMMARY OF PHEASANT STATISTICS FOR SOUTH DAKOTA AND OTHER STATES, 1947-62

	Pre-Hunt Estimate (millions)				South Dakota		
Year	South Dakota	North Dakota	Nebraska	Birds Per Mile Iowa[1]	Adjusted[2] Spring RMCS	Winter[3] Sex Ratio	Bag Check Age Ratio[4]
1947	6.977	....		0.34	......	75	....
1948	9.602	2.023		0.74	0.64	60	8.58
1949	8.059	1.593		0.86	1.42	53	6.24
1950	3.202	0.611		0.72	0.70	45	10.68
1951	5.964	0.705		0.61	0.89	63	8.22
1952	6.107	0.620		0.78	0.41	55	5.74
1953	4.919	....		0.62	0.58	43	9.06
1954	6.244	0.668		1.28	0.47	41	10.26
1955	6.347	0.835	2.536	1.78	0.55	37	9.58
1956	4.278	1.033	2.156	1.64	0.66	39	12.16
1957	5.891	0.910	4.308	1.75	0.46	34	15.04
1958	11.125	1.632	7.606	2.51	0.51	43	10.18
1959	7.498	0.398	4.910	1.72	1.19	40	5.40
1960	9.547	0.822	5.939	2.09	0.57	24	22.32
1961	11.002	....	6.552	1.92	0.62	28	12.30
1962	7.7 estimated				0.66	26	17.62

[1]Prior to 1954, counts were taken in early October; beginning in 1954 they were taken during the first two weeks of August.
[2]Adjusted for wind velocity, shown as birds per mile.
[3]Cocks per 100 hens.
[4]Twice the number of young cocks per adult cock bagged.

became available to compute the Nebraska P_1 (Table 2) in the same way as the South Dakota P_1, a highly significant (.01) correlation was found, $r = .942$. Figuring North Dakota's P_1 from 1948 to 1960, excluding 1953, a year of closed season—allowed the calculation of a significant (.05) correlation, $r = .610$. Since adequate pre-season sex ratio estimates for Minnesota are lacking, the correlation coefficient (.561) for their statewide kill estimated from mail survey (Table 1) and South Dakota P_1 was calculated, and found significant (.05). No correlation was observed with Iowa conservation officer roadside counts taken in early October from 1947-53. From 1954 to 1961, when these counts were taken during the first two weeks of

August (Table 2), there is a significant (.05) correlation, $r = .754$. No significant correlations can be demonstrated for data from other states in the Midwest.

No significant correlations between South Dakota P_1 and the combined kill from other states can be demonstrated. However, if we disregard population level, and test correlation of percentage change in South Dakota P_1 against the percentage change in lumped kill from other states,[1] we attain significance at the .05 level. When kill estimates are totalled for all states, they show a pattern of a low year followed by an increasing population for the next two years. The exception to this pattern was in 1957. Even with the flaw in 1957, the marked rhythmicity of the data is remarkable.

States to the east of Minnesota and Iowa appear to be loosely linked together in a different population-trend pattern than seen in the states showing correlation with South Dakota. It should also be mentioned that records pertinent to pheasant population trend in various states as summarized by Wagner (1961, page 195) do not show the same periodicity prior to 1947 as they have shown since. Perhaps we are examining too short a series of years to make any positive statement regarding the periodicity of pheasant fluctuations. Based on the past 16 years, however, we do have reason to anticipate that the western portion of the Midwest pheasant range may continue to experience population lows every three years.

ANNUAL MORTALITY FLUCTUATIONS

Using P_1 estimates in conjunction with other population indices, we can examine many facets of annual adult mortality variations. Wagner (1957) suspected late-summer mortality in the pheasant hen, brought several lines of evidence to bear on the problem, and discussed some of its implications. Generally, however, little light has been shed on adult pheasant mortality from year to year.

The inconsistencies of bag-check age ratios has long posed a problem to pheasant researchers. Most writers have dwelt on the bias introduced by differential vulnerability of adult and juvenile cocks to the gun, and variations of proportions of cocks harvested (Stokes, 1954; Nomsen, 1956; and others). Evidence for this approach to explain age-ratio discrepancies seems insufficient to the author. As reported earlier, varying mortality would be capable of gross distortion of cock age ratios taken in the hunt. One can readily see that cock age ratios corrected for sex ratios are a result of both production and adult cock mortality. It was the favorable-appearing age

[1]Using data from North Dakota, Minnesota, Wisconsin, Michigan, and Indiana from 1948-60, with an estimated kill of 150,000 for the 1953 closed season in North Dakota.

ratios generally obtained in the fall bag check (Table 2) during years when population decline occurred despite a high spring breeding population, that prompted the author to search out variations in annual mortality.

There are at least four main lines of evidence to work with in assessing varying adult mortality from year to year: (1) post-hunt (P_2) estimates ($P_2 = P_1 - K_T$) which may be divided into P_2 cocks (P_2 cocks $= P_2 - f_2P_2$) and hens (P_2 hens $= f_2P_2$), and compared with the cock- and hen-per-mile indices in the RMCS of the following summer; (2) P_2 cocks and hens may be compared with the P_1 cocks and hens of the next year, using the RMCS to determine the numbers of cocks and hens in P_1; (3) P_2 cocks and hens may be compared with the P_1 cocks and hens of the following fall as determined by bag check age ratios; and (4) by applying the calculated reduction of cocks and hens as a result of the hunt to the summer RMCS indices, and comparing these indices (now an estimated post-hunt cock- and hen-per-mile index) to the values of the following summer. These methods will each be further explained. They combine calculated estimates and observed indices in several ways.

P_2 and RMCS Indices

By subtracting the total kill (K_T) from the pre-hunt (P_1) estimate, we derive a post-hunt (P_2) population figure. Using the following winter's sex ratio, this can be separated into P_2 cocks and hens. These may either be divided into the adult cock-per-mile and hen-per-mile indices of the following year or handled in many other ways. The author has chosen to use the difference between the 1.81 million cocks in the fall of 1947 and the figure of 0.50 cocks per mile in the summer of 1948 as a "percentage of loss" (Table 3). No

TABLE 3. SUMMARY OF SOUTH DAKOTA PHEASANT STATISTICS, 1947-62

	Post-Hunt (millions)		Post-Hunt Summer RMCS (birds/mile)		Summer RMCS (per 10 miles)			Pre-Hunt Composition by Bag Check (millions)		
Year	Cocks	Hens	Cocks	Hens	Cocks	Hens	Young	Cocks	Hens	Young
1947	1.81	3.02	0.64	1.07	0.52	0.49	1.46	....	....	....
1948	2.25	4.26	0.74	1.39	0.50	0.55	2.09	0.854	1.425	7.323
1949	1.67	3.71	0.66	1.46	0.38	0.55	2.24	0.883	1.668	5.508
1950	0.96	1.51	0.41	0.64	0.27	0.32	0.77	0.230	0.512	2.460
1951	1.51	2.75	0.62	1.13	0.39	0.48	1.58	0.553	0.868	4.543
1952	1.19	2.78	0.67	1.54	0.41	0.57	2.42	0.713	1.298	4.096
1953	0.93	2.25	0.51	1.25	0.39	0.55	1.78	0.397	0.928	3.594
1954	1.04	2.80	0.48	1.29	0.33	0.48	2.06	0.456	1.105	4.683
1955	1.14	2.90	0.61	1.54	0.34	0.54	2.50	0.478	1.287	4.582
1956	0.64	1.88	0.39	1.12	0.38	0.49	1.68	0.272	0.692	3.314
1957	1.20	2.77	0.60	1.39	0.31	0.52	2.12	0.310	0.913	4.668
1958	2.10	5.24	0.96	2.40	0.45	0.85	3.80	0.825	1.905	8.395
1959	0.84	3.48	0.39	1.61	0.46	0.80	2.21	0.842	2.106	4.550
1960	1.28	4.57	0.44	1.58	0.25	0.62	2.42	0.348	1.439	7.760
1961	1.30	5.03	0.59	2.25	0.40	0.81	3.71	0.652	2.328	8.022
1962					0.32	0.65	2.57	0.342	1.325	6.033

matter which way the data are handled, we look for differences between the resultant figures among the various years. As seen in Figure 2, the largest "percentage change" (highest mortality) is found in the low years, with the exception of 1953. In general, cock- and hen-mortality curves move in unison, the correlation coefficient being .871, highly significant at the .01 level. The highest survival is indicated for the year succeeding the low, with the exception of 1960.

P_2 and P_1 by RMCS

The proportion of adult cocks and hens seen in the summer RMCS can be used to figure the actual numbers of adult cocks and hens in the P_1. For example, if one sees 15.92 per cent adult cocks (0.50 cocks per 10 miles) among all birds observed in the 1948 summer RMCS (3.14 birds per 10 miles), he can then assume that 1.53 million of the 9.60 P_1 are adult cocks. The percentage loss from 1.81 (P_2 cocks) to 1.53 is 15 per cent. Again, not the absolute values, but the differences in values between years are important. When graphed (Figure 2), these percentages point to high mortality in the low years. Cock- and hen-loss curves move nearly in unison, with the correlation coefficient (.897) highly significant at the .01 level.

P_2 and P_1 by Bag Check

P_2 cock and hen figures can be matched against P_1 cock and hen figures as determined by bag check to compute a percentage loss from fall to fall. The P_1 population numbers of adult cocks and hens are figured as illustrated by the following example for 1948:

	x = 853,511 cocks
Winter Sex Ratio	1.67x = 1,425,363 hens
Young Cock per Adult Cock Bag Ratio × 2	8.58x = 7,323,000 young
	11.25x = 9.602, or P_1.

The use of the above calculation (Table 3) assumes no differential cock and hen mortality, a reasonable assumption for establishing trends based on the foregoing sections. The results in Figure 2 depict the highest mortality in the low years.

P_2 RMCS and P_1 RMCS

When an adjustment is figured for cock and hen kill during the 1947 hunting season, the RMCS of 1947 can be compared with that of 1948, to determine the degree of mortality ensuing during the intervening year. Such an adjustment is possible through the calculations used in the P_1 formula. The P_1 cocks (determined by RMCS) minus the kill of cocks (K_c) divided by the P_1 cocks gives the per

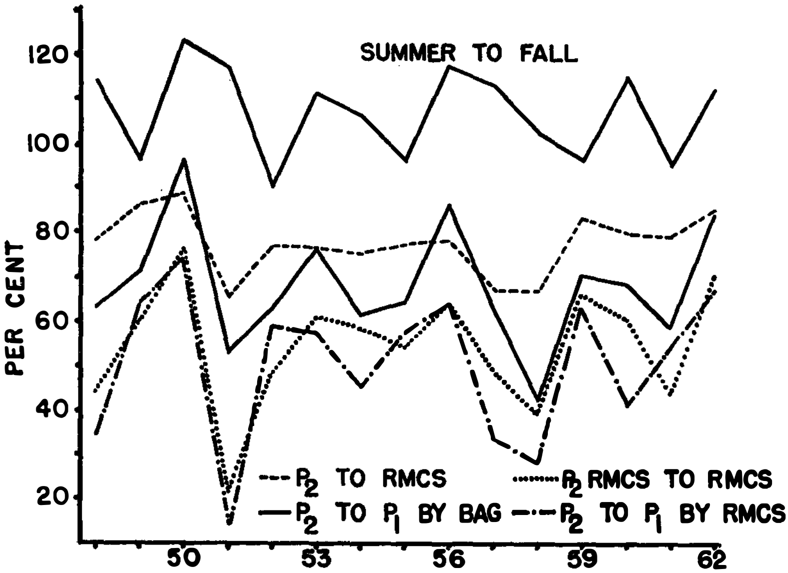

Fig. 2. Annually varying mortality of adult pheasants shown as a "percentage loss" between population indices, and mortality between summer and fall, South Dakota, 1947-62. (For purposes of clarification, the summer-to-fall curve has been set upward by adding 50 points to each of its values. Similarly for other curves, 10 points—P_2 to P_1 by bag, and 5 points—P_2RMCS to RMCS.)

cent of cocks remaining; similarly for hens. The cock-per-10-mile index plus half the young is then multiplied by the per cent cocks remaining to give a post-hunt RMCS figure; similarly for hens. A per cent loss may then be calculated directly between the P_2 RMCS and the summer RMCS figures (Table 3). As seen in Figure 2, the greatest mortality occurs in the low years. Correlation of cock and hen loss was highly significant ($r = .857$, .01).

Summer-to-Fall Mortality

If we assume that the summer RMCS would sample the population in a similar way as a gun sample in the hunt, and if cock mortality was similar from year to year from August 1 to the hunting season, then young cock per adult cock ratios from bag check and the RMCS adjusted for spring sex ratio would be expected to yield similar results—but they do not. This would seem to indicate that mortality and survival influences continue on until the hunt at varying rates. If we figure a direct percentage loss from twice the numbers of adult cocks and hens present in the RMCS P_1 and the number indicated by bag check (Table 3), we can graph the mortality curve shown in Figure 2. Again, cock and hen mortality was highly significantly correlated ($r = .840$, .01).

The summer-to-fall curve indicates that high mortality continues in the fall of low years, with the exception of 1959. While the other "summer" mortality curves (figured from the RMCS) have shown 1959 mortality to approximate that in other low years, the summer-to-fall curve indicates a period of high survival in 1959 and high mortality in 1960. Comparing this information with the "P_2 and P_1 by bag check" curve, where 1959 and 1960 adult mortality are both moderate, we may be led to believe that the period from August 1 to the hunt may contribute a sizeable share of mortality occurring during the year. The year of 1959 is the only low year where the age ratio in the bag check was not distorted higher than seemed reasonable (Table 2). Another fruitful comparison is that of 1949 and 1950 and 1952 and 1953 mortality on RMCS-computed mortality curves, which all indicate relatively high mortality for all four years. Loss from summer to fall as shown in Figure 2, however, indicates much higher survival in 1949 and 1952—substantiated by a widespread difference in the "P_2 and P_1 by bag check" curve. This again points up that late-summer to early-fall mortality may be a substantial part of the yearly total in some years.

The late-summer and early-fall period corresponds with an abundant food supply and the absence of severe weather influences. However, it does coincide with a period of low body weights and stresses of the moult which may contribute to increased mortality.

Fall-to-Spring Mortality

In order to adequately assess fall-to-spring mortality, it is necessary to adjust the spring RMCS (conducted in early May) bird-per-mile indices for varying wind speeds (Dahlgren, 1959). During the winters of 1954-59, snow cover was light to moderate and field checks revealed no measurable winter mortality due to bizzards while in most other years, observable blizzard losses ranged from light to heavy. During this period the relative change between P_2 indices and spring counts appeared to be due to wind-velocity changes, as follows.

Year	Wind Speed (mph)	"Per Cent Loss"
1954	10.8	84.0
1955	16.7	91.9
1956	16.2	90.3
1957	13.3	85.7
1958	10.3	84.9
1959	13.8	88.0

Wind speed as shown above is the average of four readings daily, taken at six stations scattered over the state for the six-day survey period. The "per cent loss" represents the change between the P_2 of the preceding fall and the current spring RMCS birds-per-mile index.

The correlation coefficient of the above comparison was highly significant ($r = .955$, .01). An average of 1954 and 1958 wind speed and " per cent loss" was used against the other years to calculate correction factors by which the spring RMCS figures could be multiplied to adjust them to the 1954-1958 base. A regression line was then fitted ($Y = - 0.64 + .144 \times$), and from this slope, data for all years was corrected for speed variation. Thus we have a corrected series of spring RMCS indices (Table 2) with which to compare P_2 indices from the preceding fall, and in the next section of this paper, with summer and fall figures from the same year.

Two main methods of calculating fall-to-spring loss are available: (1) P_2 indices and the spring RMCS results, and (2) the summer RMCS indices of the preceding year adjusted for hunting season kill (P_2 RMCS) measured against the spring RMCS results. Fall to spring loss (Figure 3) calculated by both methods show somewhat similar curves. Mortality, with exception of more extreme variation in the early years, appears as a more stable picture of loss than that shown by yearly-mortality curves.

Mortality curves for the sexes are highly significantly correlated. The correlation coefficient for method number 2 above was .918. This accords with counts of dead birds after blizzard and starvation losses, which have shown both sexes to be approximately equally affected.

Spring-to-Fall Mortality

At least two approaches for assessing spring-to-fall mortality are available; (1) the spring RMCS bird-per-mile indices against the summer RMCS, and (2) the spring indices against the adults in P_1 as determined by bag check ratios. Curves from the two approaches (Figure 3) differ in that more mortality variations between years is shown in the latter. The tendency for peaks of mortality every three years (the low years) is evident in both curves. Mortality by the sexes is again highly significantly (.01) correlated. The correlation coefficient for method number two above was .893.

Mortality Variations Within the Year

Having a picture of the fall-to-spring loss (P_2 to spring RMCS) and the spring-to-fall loss (spring RMCS to P_1 by bag check), we may assess the importance of each in the yearly picture. There is no

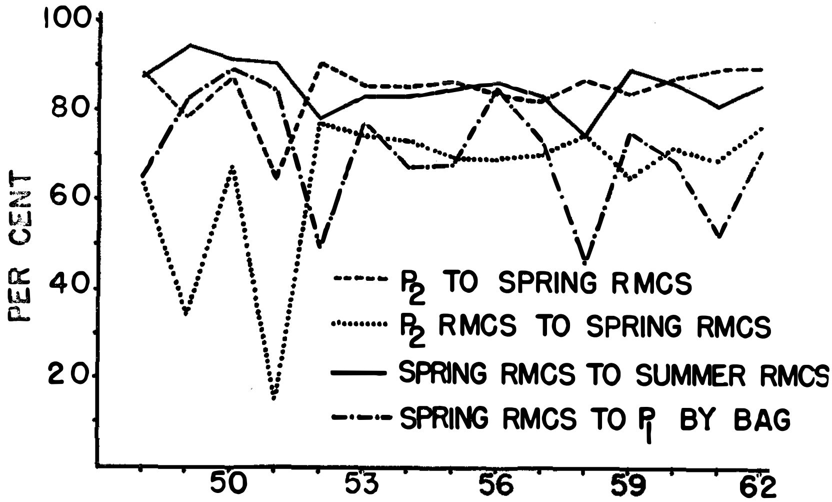

Fig. 3. Seasonally-varying mortality of adult pheasants from summer and fall to spring, and from spring to summer and fall, shown as a "percentage loss" between population indices, South Dakota, 1947-62.

significant correlation ($r = .245$) between fall-to-spring loss and total yearly loss (P_2 to P_1 by bag check), indicating that fall-to-spring mortality is a minor part of the yearly loss. There is a highly significant correlation ($r = .661$, .01) between spring-to-fall mortality and total yearly mortality. This indicates that adult pheasant mortality from spring to fall is the major share of the yearly loss.

When working similar correlations using the periods from spring to summer (spring RMCS to summer RMCS) and summer to fall (August 1 to the hunt), we find no correlation between the spring-to-summer period and the summer-to-fall period ($r = .333$). There is no significant correlation between the summer-to-fall period and the yearly total ($r = .431$). There is a significant ($r = .520$, .05) correlation between the spring-to-summer period and the yearly loss. These calculations suggest that the major share of annual mortality occurs from spring to summer, with the next most important mortality period being from summer to fall. The least important segment of the annual mortality occurs from fall to spring.

An inverse relationship between summer-to-spring and spring-to summer mortality can be demonstrated to be significant ($r = .631$, .05). A correlation test between fall-to-spring and spring-to-fall mortality curves suggests an inverse relationship also, with a correlation coefficient of .512, barely under the .05 level (.514 at 13 d. f.). If over-winter mortality were seen to play a more important role in yearly mortality, rationalizations could be more readily made to explain why this inverse relationship exists. At present, the meanings of relationships are too obscure for presentation of possible explanations. It can be stated that no significant correlation exists between population density and mortality.

Wagner (1961) concluded, ''one preliminary suggestion that fall-to-spring mortality may not vary markedly between most years'' and concluded (1957) that the major share of seasonal hen loss occurred in the summer. Stokes (1954) gave the opinion, ''the bulk of the mortality between the 1949 and 1950 hunting seasons occurred in winter''. Data from several other Midwest states are complete enough to reveal patterns of seasonal loss through calculations similar to those used in this paper, and an analysis of these data will shed further light on the problem of mortality.

Having presented many correlations of population trend and mortality patterns, we are now able to make other useful comparisons, particularly with reproduction. Time and space do not permit their elaboration here. It is significant that we have added another piece to the picture puzzle of population mechanics, suggesting new approaches for fitting the next piece.

SUMMARY

Calculation of pre-hunt indices for the period 1947-62, which are in agreement with other surveys showing population trend, has shown rhythmic trends with a ''low'' year every three years, followed by two "better" years. Data from sister states of North Dakota, Nebraska, Minnesota, and Iowa have shown similar patterns, while states to the east of these appear to follow a different pattern of population trend. If the future follows the relatively precise regularity of the past 16 years, the western portion of the Midwest pheasant range may expect good pheasant years in 1963 and 1964 and a poor year in 1965.

Inconsistencies in bag-check age ratios, which implied high cock mortality in low years, prompted analyses of annually varying adult mortality. High adult mortality was found to occur during low years, and cock loss was found to be closely correlated with hen loss. The highest annual survival generally occurred in the year following the low. An assessment of the seasonal mortality pattern from fall to fall showed the bulk of mortality occurring from spring to summer, the next most influential period for mortality from August 1 to the hunt, and the least important period for mortality from fall to spring. An inverse relationship was demonstrated between over-winter mortality and spring-to-summer mortality.

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DR. FRED WAGNER [Utah]: Are you saying that reproduction is correlated to mortality and the two are correlated with population increases and decreases?

MR. DAHLGREN: Fred, I'm sure it was obvious to you that there was a correlation between the reproduction. Space did not permit including it in this paper. It will be published and, therefore, I thought that we wouldn't discuss it too much here. But it is obvious that reproduction is correlated with mortality and the two are correlated with population ups and downs.

DR. WAGNER: The other question was that you mentioned having an inverse gain ratio with population change. One thing that puzzles me, there was data quoted that showed apparently that you get an inverse correlation between your age ratio from your bag data and your age ratio that comes from your summer survey. I wonder how you reconciled this?

MR. DAHLGREN: That was shown, Fred, in some of the fall mortalities. This figure was shown in the summer to fall mortalities.

DISCUSSION LEADER SANDFORT: Bob, this is very interesting and as I interpret your discussion here you have shown that the bulk of adult mortality occurs in the spring and fall as opposed to the fall and winter months. I think this is a little different idea from what we have had in the past. From a practical management standpoint, would you recommend that the hunting seasons be advanced in fall to perhaps September or October to harvest these birds prior to the time they experience this late summer to fall mortality? Would this be a logical application of your studies?

MR. DAHLGREN: I imagine that it would. There are a lot of factors to weigh besides the pheasant population itself in setting the hunting season. If the administrator is apprised of this knowledge it is up to him to make a decision, but definitely you would be shooting more birds if you set the season earlier.

MR. SANDFORT: Would you care to comment at what time the season should be set?

MR. DAHLGREN: No, I wouldn't care to set a particular time. That's up to the individual states. You want to wait until your birds are big enough to make it worthwhile hunting and not delay much beyond that point.

MR. DAVID LYON: You have made extensive studies along these lines. Have you any indication in your test areas during these years when the mortality of hens was high that your egg per hen figure would be correspondingly lower?

MR. DAHLGREN: This information we have here is State-wide data. Our nesting areas are small and scattered. We have not attempted any definite correlations there. That will come at a later paper where we tie this mortality in with reproduction.

MR. CHARLES LOVISS [California]: In your P1 chart coefficient between the States, how did you correlate the criterion as to whether or not you had comparative observations for comparative purposes?

The other question, do you think that the ability of your rural mail carriers to to observe the birds from year to year, and I don't mean whether the mail carriers need glasses or not, but does the vegetation, let's say, from year to year hinder their ability to observe these birds?

MR. DAHLGREN: Obviously rural mail carriers are not giving us perfect results. However, we have a lot of confidence in the data they have given us. I might mention that P_1 curves were shown to be valid in trends by every other population index that we had in the State and that's why we felt that this was a good one to use.

The Nebraska and North Dakota P_1's were calculated in the same manner as South Dakota's and compared as a series of years.

WILD TURKEY INTRODUCTIONS IN NEBRASKA

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Early records show that wild turkeys (*Meleagris galopavo*) occurred in Nebraska, but were extirpated by 1915 (Latham, 1956). These were probably the eastern subspecies, *M.g. sylvestris,* (Mosby and Handley, 1943). Turkeys were widely distributed in the eastern part of the state and ranged westward along the riparian communities of the major drainage systems to approximately 101° longitude (Jones, 1959), and may have reached the Rocky Mountains by way of the Platte and South Platte Rivers (Ligon, 1946). Probably turkeys were not native to the Pine Ridge in northwestern Nebraska (Mosby, 1959).

Numerous attempts were made to re-establish wild turkeys in Nebraska by private groups and by the State Game Commission. All of the released stock was pen-reared, and either succombed or became glorified barnyard fowls. The Missouri Conservation Commission, with releases of 14,000 game farm birds over an 18-year period, recorded similar failure of pen-reared stock (Lewis, 1961). Nebraska's recent wild turkey program has dealt entirely with wild-trapped stock. Introductions consisted of 28 Merriam's turkeys (*M.g. merriami*) in 1959 in the Pine Ridge, and 518 Rio Grande turkeys (*M. g. intermedia*) in 1961 and 1962 through the central and south-central portions of the state (Figure 1).

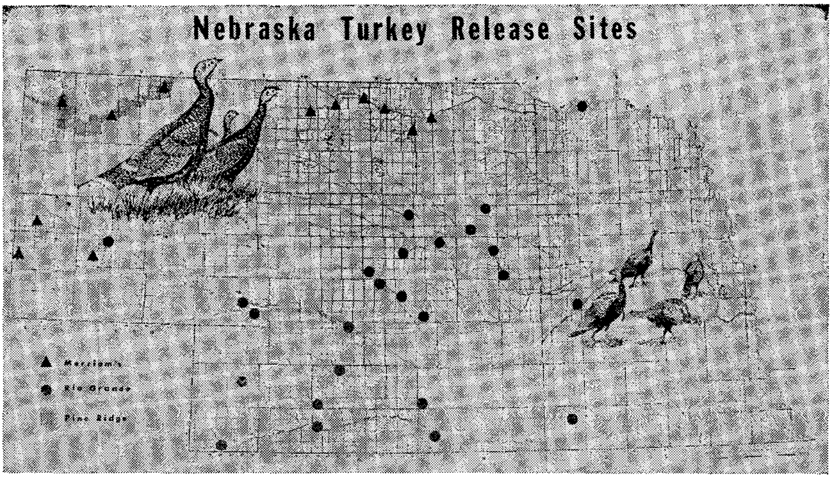

Figure 1

MERRIAM'S TURKEY

Pine Ridge

The Pine Ridge is located in northwestern Nebraska. It is a narrow escarpment about 90 miles long, with the greatest width of 20 miles near its center. The extent of the area occupied by timber, interspersed with grassland and croplands, is approximately 630 square miles. The greatest elevation of 5,280 feet occurs at the western end of the Ridge. Climatological averages from the Fort Robinson Weather Station for 1950 to 1959 were: 15.9 inches of precipitation and 47.1° F. mean with extremes of 110° above and 35° below zero.

The Pine Ridge contains a system of rugged canyons and buttes intersected by numerous small streams. Although a formation of the prairie, the Ridge has mountainous topography similar in many respects to the Black Hills of South Dakota. The soil is of a fine sandy loam texture (Rockie *et al.,* 1922). Major land use in the Ridge is ranching with the necessary crop production for wintering cattle. Crops include oats, alfalfa, wheat, corn, barley and rye.

The predominant vegetation consists of open stands of ponderosa pine (*Pinus ponderosa*) with understories of native and introduced short and mid-grasses. Grasses include gramas (*Bouteloua* spp.), buffalo grass (*Buchloe dachtyloides*), big bluestem (*Andropogon gerardi*), little bluestem (*A. scoparius*), switchgrass (*Panicum virgatum*), needle-and-thread (*Stipa comata*), crested wheatgrass (*Agropyron cristatum*) and intermediate wheatgrass (*A. intermedium*). Forbs include soapweed (*Yucca glauca*), sand sage (*Artemesia filifolia*) vetches (*Astragalas* spp.), sunflowers (*Helianthus* spp.) and a variety of other composites. The more mesic sites support a growth of deciduous trees with an understory of shrubs. Common hardwoods are boxelder (*Acer negundo*), cottonwood (*Populus deltoides*) and ash (*Fraxinus pennsylvanica*). Shrubs include buckbrush (*Symphoricarpus occidentalis*), chokecherry (*Prunus virginiana*) and wild rose (*Rosa* spp.).

Primary game animals are mule deer (*Odocoileus hemionus*) and whitetails (*O. virginianus*). Predators include the bobcat (*Lynx rufus*), coyote (*Canis latrans*), striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), red fox (*Vulpes fulva*), and hawks and eagles.

Preliminary reconnaissance of the Pine Ridge in 1958 indicated suitable habitat for Merriam's turkeys. Twenty landowners, controlling about 24,000 acres, signed cooperative release agreements. Surveys of these areas showed the following percentages of types: pine woodland—46; deciduous woodland—4; grassland—32; grain crops—13; and alfalfa—5.

Arrangements were made for obtaining wild-trapped birds from Wyoming and South Dakota, and in early 1959 Nebraska's wild turkey program was initiated. Twenty-eight Merriam's turkeys were released at two sites in February and March, 3 toms and 17 hens on Cottonwood Creek northwest of Crawford, and 3 toms and 5 hens on Deadhorse Creek south of Chadron.

Following their release, the birds remained relatively close to the release sites. With the onset of breeding, movement of individual hens was reported and they became more widely distributed. The more aggressive toms strutted and engaged in mock battles as early as the first of the year, but it was during the month of March that courtship and mating activities began in earnest.

During the past four breeding periods some reports of nesting birds were received. However, either before they could be checked or soon after being checked, the nests were abandoned. These personal experiences confirm previous conclusions (Dalke *et al.*, 1946; Mosby and Handley, 1943) that wild turkeys will tolerate little molestation by man or other mammals.

Landowner reports indicate nesting sites were located on the higher, drier slopes bordering timber cover and within one-half mile of water. Brood observations indicate that during the four-year period, the peak of hatching occurred during the first week of June. Reproduction was apparently dependent upon weather during the latter half of incubation and the first two weeks in the poult's life. At this time hail and rain can be disastrous to reproduction, but fortunately this has not yet occurred in the Pine Ridge area.

Turkey broods were usually first reported in late May or early June. Early in the season broods were observed primarily along stream courses where vegetation was denser. The numbers of birds observed varied from one hen with one young to 5 hens with 50 young. Observations of 101 hens and 897 young over the four-year period showed an average of 8.88 poults per each hen accompanied by young. Hoffman (1962) found an average of 6.58 poults per brood in Colorado from 1950 to 1957.

The initial 28 birds ranged within five miles of the release sites during the first nesting period and wintered their broods in the same area. The Cottonwood Creek flock, where only juvenile toms were released, increased from 20 to 91 birds. As found in Montana (Eng, 1959), sub-yearling toms are apparently capable of reproduction.

Two flocks totaling 127 turkeys were located the first winter. Two birds were lost during the winter, one from bobcat predation and one from unknown causes.

As the second nesting period approached, the 125 birds dispersed and found nesting sites in the various creek drainages. Some moved to near the Wyoming line and thus extended the turkey range about 18 miles westward. The Cottonwood Creek population extended their range rapidly and nearly all suitable drainages were inhabited by turkeys. The Deadhorse Creek population did not disperse as rapidly and wintered in the Chadron Creek and Deadhorse drainages. Ten winter flocks, totaling 309 birds, were found in the Pine Ridge during the second winter.

Distribution of turkeys throughout the Pine Ridge was accelerated by trapping nine birds from the Cottonwood Creek population and transplanting them to the northeastern part of the Ridge. A total of 930 birds in 17 concentrations was known and studied during the winter of the third year.

By the fourth year turkeys had moved into Wyoming through the Pine Ridge extension and into South Dakota through the Hat Creek drainage. Nesting birds and summer broods were reported in about 80 per cent of the suitable drainages in the Pine Ridge. One group of birds, prior to nesting, traveled approximately eight miles across rangeland and cropland to the Niobrara River near Box Butte Reservoir. This pilgrimage may have been an indication of nest site saturation in some areas.

It was estimated that there was a minimum of 3,000 birds in the Pine Ridge during the fall of 1962. This explosive pattern corresponds to results of initial releases in other western states (Eng, 1959).

Trapping and Transplanting in Nebraska

Over a two-year period, commencing February 1961, 94 Nebraska-trapped birds were released at 10 sites in the Wildcat Hills and Niobrara River System. The original Cottonwood Creek release site was selected for trapping. A modified Dill-Thornsberry projected net was used for trapping.

During the trapping operation in January and February it was found that the turkeys followed a definite pattern in their activities. The birds left their roost trees between 45 and 15 minutes before sunrise and spent considerable time in courtship displays. On windy days they spent much of their time feeding and loafing in protected canyons near their roost trees. On sunny days the birds utilized the timber-covered southwest slopes. Evening roosting activities occurred between 15 minutes before and 15 minutes after sunset. During extremely overcast days, birds left the roost later and returned to roost earlier.

The turkeys utilized large cottonwoods as roost trees during the winter and spring, and used ponderosa during the summer and fall. Ligon (1946) in New Mexico, found extremely few cases of Merriams' roosting in cottonwoods, particularly in winter. Hoffman (1962) in Colorado found that tall cottonwoods and junipers were commonly used when ponderosa pine tree roost trees were not available.

Since trapping was from flocks which had not experienced molestation, capture was relatively easy. In the early stages of trapping, much care was taken to camouflage equipment and personnel properly. However, adverse weather prompted elimination of attempts at concealing the equipment, and this did not appear to reduce trapping success. Miller (1958), who modified the trapping equipment for work with waterfowl in Nebraska, stated the equipment resembled debris and that birds were less wary of the projectile.

Although snow cover was usually required for baiting the birds, prebaiting was not necessary until shortly before the trapping began. It was more profitable to study the flock's daily feeding habits and locate the equipment accordingly than to attempt to bait-in the flock to a specific trap site. Initially, shelled corn was used for bait but later cracked corn and wheat were used. The bait change was made to reduce the rate of consumption and thus provide a better chance of having a mixed-sex group on the baited area.

Following netting, some turkeys fought the net and became entangled, but most of them stood quietly. The birds, if allowed, would escape readily out of the sides of the net.

Captured birds were aged, sexed and banded. They were then transported in cardboard boxes. Shipping crates made of poultry netting were used in our original shipment of birds, but some mortality and considerable de-feathering occurred. In later trapping-transplanting operations large cardboard cartons were utilized. We found that they made good one-shot crates with a minimum of de-feathering resulting. Of 95 birds trapped, the total mortality was one hen (struck by the net).

During the first year most of the birds were crated and released within 24 hours following capture, but a few were crated as long as 66 hours without apparent ill-effects. One group of three was crated for three days before release due to snow-closed roads. One of the birds seemed in poor condition at the time of release and the carcass was later found at the release site.

Other Merriam's Releases

Nine release sites were selected in the Wildcat Hills and Cheyenne escarpment and along the Niobrara River. A total of 83 turkeys was introduced at these sites during 1961 and 1962.

The Wildcat Hills and Cheyenne escarpments are located in the west-central portion of the Panhandle, paralleling the North Platte River. Created by the erosion of the North Platte River and Pumpkin Creek and its tributaries, the range is a system of numerous rugged canyons and spurs intersected by seeps, springs, and streams. The soil is of a fine sandy-loam texture. Annual precipitation averages approximately 15 inches. Principal land use is cattle grazing. However, there is considerable cropland in the valley along the foot of the northern slopes. Crops include wheat, oats, corn and barley, with sugar beets produced in the more fertile, irrigated sections. Range cover includes ponderosa pine, juniper (*Juniperus virginiana*) and grasses.

Releases of 11 toms and 19 hens were made at three sites in this area. Limited data show courtship activities commenced immediately after the birds were released and some reproduction did occur.

The Niobrara River traverses most of the northern portion of Nebraska, becoming wider and deeper as it proceeds eastward. Vegetation changes from short-grass to ponderosa pine-juniper and topography becomes more rugged. Important deciduous trees include cottonwood, bur oak (*Quercus macrocarpa*), boxelder, ash and hackberry (*Celtis occidentalis*). Potential Merriam's turkey habitat is about 250 square miles, along about 150 miles of the river and its major tributaries.

Fifteen toms and 38 hens were released at six sites along the Niobrara River. Limited data indicate relatively high reproduction. Results from one breeding season at three sites showed 127 turkeys present from releases of 7 toms and 18 hens. Young were observed at all other sites, but total numbers have been difficult to evaluate.

White turkeys have been seen at three sites, and three birds were collected for examination. They appeared very similar to domestic white turkeys, and possibly indicate an ancestral cross with this strain.

Hunting Season, 1962

Following four years of production, and with an estimated 3,000 turkeys in the Pine Ridge, the first open season was authorized in 1962. Several reasons prompted the season: carrying capacity of portions of the range was being approached, as evidenced by movements of nesting birds to marginal or submarginal sites; several hundred hunters would be provided with recreation at no cost to the resource; local crop depredations might be alleviated; less wary and hybrid birds could be removed, resulting in a more desirable game bird; birds were being lost to Wyoming and South Dakota; and possibly, high production could be maintained for a longer period.

State legislation restricted legal firearms to shotguns. Regulation placed legal shotguns as 10 to 20 gauges, inclusive, and only shot sizes of 2 to 6 were permitted. Season length was nine days, November 10 to 18, with the first two days overlapping the end of deer season. Shooting hours were one-half hour before sunrise to one-half hour after sunset. The limit was one-bird of either sex. Five hundred special permits were authorized, and interest was so high that all were taken within 10 days.

Prior to the season birds were unwary, with approaches within 10 yards not uncommon. Some hunters and landowners anticipated a slaughter. At one location, efficient engineering of the hunt by the landowner resulted in successful bags of 24 turkeys by 24 hunters within a period of a few minutes. After that the birds became increasingly difficult to bag.

Successful hunters were required to check their turkeys, with plumage intact, at one of three check points, where various biological and success data were obtained. A total of 281 birds was checked, indicating that 56.2 per cent of the permittees were successful. Based on 424 returned questionnaires, 17.6 per cent of the permittees did not hunt. The indicated success of active hunters was 68.2 per cent, comparable to the highest success in Wyoming which ranged from 36.6 to 67.1 per cent between 1955 and 1961 (Ted Baker, pers. comm.).

As a matter of interest, the first mailing of questionnaires resulted in 222 returns, and expansion of the data indicated a kill of 345 birds (22.8 per cent high). A second mailing provided 202 additional returns, and the 424 cards indicated a kill of 306 turkeys (8.6 per cent high). Based on check station data, individual hunters reported accurately. The discrepancies were due to non-response or slower response from unsuccessful hunters.

With an open season of nine days, 60.5 per cent of the kill occurred on the first day and 85.8 per cent on the first three days. Sixty-nine per cent of the successful hunters bagged their birds in less than one day of hunting and only 2.5 per cent required more than three days. Successful hunters averaged 1.45 days or parts thereof in the field, while unsuccessful hunters spent an average of 2.31 days.

Sex and age composition of the 281 birds was as follows: juvenile male—126; juvenile female—79; juvenile, no sex data—1; adult male—47; adult female—28. The preponderance of young males to young females probably resulted from picking one of the larger birds in the available flock. It is presumed that there was also some selection for adult males. Kill consisted of 61.8 per cent males with 736 young: 100 adult hens.

About 70 crops were collected for future analysis. Preliminary, cursory examination indicated oats, corn, wheat and grasshoppers as primary foods, with lesser amounts of green wheat, alfalfa and grass seeds present.

Weights were obtained from 135 intact birds, and 128 eviscerated birds (Table 1). These, together with both types of weights from seven birds, indicate that weights of eviscerated birds should be increased by 12 per cent to estimate live weights. The largest bird was an adult tom which weighted 23.3 pounds eviscerated, or about 26 pounds live weight. Average weights of birds in all groups were similar to those of Colorado turkeys (Hoffman, 1962), but males were somewhat heavier than those checked in New Mexico (McDonald, 1961).

The initial turkey season is considered successful. The number of

TABLE 1. WEIGHTS OF MERRIAM'S TURKEYS, 1962 SEASON

	Whole Birds		Eviscerated Birds	
Sex and Age	Sample Size	Average (lbs.)	Sample Size	Average (lbs.)
Juvenile Male	58	12.5	59	11.2
Juvenile Female	37	8.7	37	7.6
Adult Male	27	17.8	19	15.8
Adult Female	13	9.5	13	8.7

permits was low in an attempt to curb unfavorable reactions which always preceded the first season on other species in Nebraska. With the demonstration that hunting did not significantly reduce the turkeys, more liberal regulations should be expected in the future.

RIO GRANDE TURKEYS

During early spring of 1961 and the winter of 1961-62, a total of 518 Rio Grande turkeys was obtained from the Texas Game and Fish commission. These birds, trapped on the King Ranch in southern Texas, were from an area of 25 inches of annual rainfall. Vegetation in that region consists of mesquite (*Prosopis* spp.) and live oak (*Quercus virginiana*), plus a variety of grasses. Rio Grande turkeys have been successfully transplanted into the northern panhandle of Texas and have spread into Oklahoma and Kansas. Habitat in these regions is similar to that found along river systems in central Nebraska. Rio Grandes have also been introduced in northeastern Iowa (Haugen, 1961).

During 1961, two releases totaling 31 birds were made in early spring. Despite the lateness in the season, reproduction occurred at both sites. At one of the sites, where 17 birds were liberated, winter counts revealed at least 36 birds.

During the winter of 1961-62, a total of 548 turkeys was shipped to Nebraska via rail and truck. Shipping loss was 61 birds, favoring the trucking system for long distance transportation. Birds were released at 23 sites, primarily along river systems and in canyon areas. Nine mortalities were reported at these sites, three of which were due to golden eagle predation. The causes of the remaining mortalities were undetermined, but may have been related to the condition of the birds at the time of the release.

Reports of movements were varied. At some sites the groups stayed together and moved only a short distance. However, movements up to 25 miles (air line) were recorded, possibly because of the narrow width of cover along some river systems. Some of the extensive dispersal may have been by birds released later in the winter, at which time the breeding period was approaching.

Brood information was collected through landowners' report cards. Twenty-nine observation cards reported 52 hens and 276 young, for an average of 5.3 young per hen observed with brood. Broods were observed at 18 of 25 sites in 1962.

Mortalities of nesting birds were reported as early as June 3. Twelve nests were destroyed by alfalfa mowing, with four hens killed along with the destruction of the nests. Of the 12 nests, three were being incubated.

At one site where only juvenile toms were released, a nest with fertile eggs was found, indicating juvenile toms are capable of breeding successfully if permitted.

Population increments have been difficult to evaluate, but they have been considerably lower than in the Merriam's turkeys. This is probably due to the greater human densities and hazards in the Rio Grande habitat than in the Merriam's range. Several more years will be required before the results of Rio Grande introductions can be determined.

SUMMARY

Recent introductions of wild turkeys in Nebraska commenced with 28 wild-trapped Merriam's released in early 1959, and 518 Rio Grande turkeys released in 1961 and 1962.

The 28 Merriam's increased to 125 the first production year, more than 300 the second year, about 1,000 birds the third, and a minimum of 3,000 birds in the fourth. Distribution and range extension increased from a five-mile radius from the point of release the first year to 18 miles west of the site the second year. The third year, range extension was completed throughout the Pine Ridge area by natural dispersal and also by a transplant into the northeastern part of the Ridge. Production was high, as verified by winter flock counts.

Trapping and transplanting operations commenced in early 1961, and during two years 94 birds were transplanted to other sites in the state. Fair to good production has been realized at these release sites.

The first open season on Merriam's turkeys, confined to the Pine Ridge, was held in 1962. Of 500 permittees, 281 were successful in bagging turkeys.

Rio Grande turkeys were released at 25 sites, principally in the central and south-central portions of the state, during early 1961 and the winter of 1961-62. Broods were observed at 18 sites, but population build-up has been considerably slower than in the Merriam's turkey. Several more years will be required before the results of Rio Grande introductions can be determined.

ACKNOWLEDGMENTS

We wish to express our appreciation to Bill Bailey and John Mathisen, former Game Commission employees, who provided assistance and advice in these studies. Ed Ostermeyer and Art Zarek aided in trapping and provided us with information on populations, movements and behavior. Game Commission personnel and local ranchers, too

numerous to mention, assisted in obtaining field observations.
This work was performed under the provisions of the Federal Aid in Wildlife Restoration Act, Project W-15-R.

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DISCUSSION

MR. MEL STEEN [Nebraska]: I don't have any questions to ask but I would like to make a couple of observations that may be of interest to the group.

First, I would like to point out the significance, at least in this case, of introducing a geographic race of birds into the environment to which, at least, they have become admirably adapted. I think one of the things we do in transplanting game, particularly birds, is to perhaps overlook the significance of the adaptation of some either because of the survival of the fittest or the adaptability of the environment under which we propose to introduce these species and the environment from which they come.

Now, the Virginia turkey was introduced into Nebraska as far as I can determine off and on for the last half century or more and all these have failed. The introduction of the turkey in the Pine Ridge country has been an overwhelming success from a release of 28 birds in 1959 we went to an open turkey season for the first one in this century in Nebraska. This is phenomenal. I think we can take a lesson from this and perhaps we can take a lesson too from the fact that there may be a difference between the release of game-farm birds and wild birds. In this case, of course, they are wild trapped birds. In all of the previous introductions we have had game-farm birds. There may be some significance to that but I am of the personal opinion that the contributing factor, determining factor is that of putting in a race of species which is admirably adapted to that range.

In passing I also want to pay a comment to the great State of Texas for the very fine cooperation we have had from them in testing the Rio Grande turkey.

SMALL WATERSHED PROJECTS AND WILDLIFE

FORREST V. DURAND

State Game and Fish Commission, Nashville, Tennessee

So that there will be no misunderstanding due to my remarks, let me say at the outset that I am not opposed to watershed programs—small or otherwise; nor am I opposed to the Soil Conservation Service and its great and far-reaching program. As a matter of fact I worked for this agency for about 14 years in various capacities from labor foreman to biologist with statewide responsibilities. Watershed planning and development is the way and the answer to planning our land and water resources to meet the challenge of an ever-increasing population and the stepped-up demands of this population.

In my own State of Tennessee our Game and Fish Commission has fully demonstrated belief in the watershed program through financial outlays and through plans for further such expenditure of Game and Fish funds. We also have a long record of full cooperation with the Soil Conservation Service at various points where we have a common or potential for a common interest. I am concerned, however, at what seems to be a growing tendency to stress the development of certain resources at the sacrifice of others—in full or in part. Now this becomes of even more concern when in this process the resources developed are for private gain whereas those destroyed are public or at least quasi-public.

One of the greatest arguments for expanding the soil conservation program of working with individual farms on a countywide district basis to working with watershed areas as complete agricultural units, and of stepping up public fund expenditure for this expansion, is that what a man does on his land is of public concern if it harms his neighbor. If he plows straight up and down the hills on his farm, it is not his concern alone, but it is his neighbor's burden also. It is not his loss alone if he allows his fields, his pastures and his wood lots to erode. This affects his neighbor. It affects his community. It affects all within his watershed, if you please, and what happens in one watershed affects other watersheds. Therefore, community action is demanded, and when a community action is called for and community or regional welfare is concerned, public expenditures are justified. That is sound, but its soundness is colored if, in the process, valuable resources are overlooked, damaged, or destroyed.

It is easy to surmise that the resources I have referred to as being overlooked, damaged or destroyed, are game and fish resources for I am a State Game and Fish Director. Perhaps an eyebrow may be raised or even a scornful glance be directed at my audacity of even suggesting such a comparison between game and fish resources and others concerned here such as cropland or pasture. Perhaps they are justified. It is difficult to place a dollar sign on recreation, but I know pretty well the value of hunting and fishing in Tennessee. We have recently completed a survey in Tennessee using statistical sampling procedures and computation methods approved by the North Carolina Institute of Statistics, and we find the expenditures by resident hunters and fishermen to be about $45,000,000 annually. The sample was selected from telephone directories and 30% of the population does not have phones so this is representative of only 70% of the families in Tennessee and it did not take into consideration some 160,000 non-resident hunters and fishermen.

I think it is a matter of common knowledge that there is an excess of agricultural land and production in this country—certainly there is no shortage. Economists have estimated that by 1980 we will have 50 million acres more cropland than will be required. It would, indeed, be out of place here for me to dwell upon the various stratagems used or proposed for the expenditure of public funds to somehow bring supply and demand into balance. There is a shortage of hunting and fishing resources and areas to produce these resources, and there is a growing demand for hunting and fishing resources and facilities and for almost every other type of outdoor recreation facility. Natural resources projections prepared by Resources for the Future Inc. indicate that there is a need now for 44 million acres for outdoor recreation and the need by 1980 will be 75 million acres. This question might logically be asked: If a value cannot be established for items of short supply such as hunting and fishing areas, how from a public fund expenditure point of view can a high value be placed upon items of over-supply such as cropland—a value high enough to justify their creation through the destruction of the short supply areas?

So, how can a swap of an item in short supply for an item already over-stocked be justified, particularly if public funds are used to facilitate the swap and the already excess item goes for personal gain and the short supply items are ones of value to the public. That is exactly the tendency which is followed in economically justifying a growing number of watershed projects. Under present formulae the economic feasibility of many such projects is based upon the value of crop or pasture land converted to this usage with destruction of primary game or fish environment occurring.

It may be said that we are dealing with a production on a man's farm, that it is his land, his stream and he can do with it as he sees fit. That is so but a new factor is added when public funds are used on his property. It also may be said that watershed districts are locally controlled and governed, and policies and practices must be followed which are acceptable to local governing bodies. That leaves me just a little bit cold for I well remember when it took a tremendous selling job to get farmers to plow on the contour, to terrace, to strip crop, to follow proper crop rotation, to sow winter cover and to do the many things now generally accepted as correct soil conservation practices. I know whereof I speak for I was there. It never has been difficult to get landowners to channel and drain even at their own expense, let alone at public expense.

When I was writing farm conservation plans I could usually meet my quota by finding a farm where I could stress farm drainage work and in many instances drainage work was all that was accomplished. I feel too that this is being carried over into the watershed program. It is the easiest way to encompass large acreages into a watershed program. It is easier to meet economic formulae for it is cheaper to channel than to impound, and drainage usually facilitates development of new cropland or pasture. It is easier to sell, for it is really nothing new. It is an old weapon of exploitation being used under a conservation label.

At various meetings and in discussions with technicians having to do with these watershed programs, one hears more and more the phrase "get the water off the land." To me that is a strange and alien theory of conservation. Although as I have indicated, in the early days we did not always follow the principle or the ideal, the goal was to keep the water on the land. That water which would not be absorbed where it fell was conducted away by a slow series of steps. The idea was to conserve both soil and water. Perhaps that is still the idea but the approach is odd. I know of watershed projects in hilly country programmed around a re-channeled drainageway and normal individual-farm agriculture conservation practices —No impoundments—Why? Because the construction of impoundments cannot be economically justified. It is cheaper to build a channel. Therefore, the rainfall which cannot be absorbed upon the land must be rushed off through a drainage ditch, in the construction of which, fish and game habitat is destroyed.

It might be well to keep in mind too that only those practices directly supported by public funds or public effort can be assured of completion. There is usually a question regarding those left to the landowner's personal initiative regardless of the obligation he may have to place them into effect.

Here a somewhat frightening aspect of this picture begins to creep in. I have referred up until now to things within the boundaries of a watershed district; even though I have referred to game and fish resources as public or quasi-public interest, still they were within the confines of the district. Though their destruction through the use of public funds might be questioned, few would quarrel with a landowner for converting his own upland game habitat to pasture or cropland, or his waterfowl and shooting areas to meadows. They might view this with regret but they could not quarrel with his right and prerogative to do this even though they did question the use of public funds to help him. But what of the cumulative effects of accelerated run-off from a growing number of watersheds? What about destruction of hunting and fishing resources far outside the watershed boundaries? This is exactly the case in watershed programs on plateaus and other high areas upstream from lower level trout fishing streams. Here are destroyed resources enjoyed by thousands who benefit in no way from the watershed program upstream.

Again I ask what will be the cumulative effect of accelerated run-off downstream from many watershed projects. Won't bigger and better drainage channels be needed there? Are we heading for a condition where lowering water tables will leave our basic landscape a network of funnels rushing rainfall to the sea through a drouth stricken land—a land where increasing demands for water face a lowering water table?

Perhaps I may be an alarmist. My statement may be considered on the sensational side and without basis in fact. Let me quote some figures, facts and documented statements: 50,000,000 acres are covered by PL 566 applications in the States comprising the Southeastern Association of Game and Fish Commissioners—12 per cent of the total land area of these States. This coverage runs from 27 per cent in Kentucky down to 4 per cent in Missouri; 2,865 miles of channel work are already actually scheduled or under construction; this reaches from 424 miles in Tennessee down to 27 miles in South Carolina. A total of 258,000 acres of idle lands are in process of conversion to cropland, pasture or woodland, the latter mostly pine. The total plus side of new woodlands of this 258,000 acres is 26,000 acres. This might at first seem an asset from a Game and Fish administrator's point of view but unfortunately a good deal of this comes from idle land providing at the present good habitat for which purpose pine trees are no substitute. Then in the process, many prime and irreplaceable bottomland hardwood areas providing good wildlife habitat are being converted to cropland and pasture fields. As an example of this, one of the watersheds in Tennessee plans to reforest 4,410 acres but the net gain in woodlands is only 568 acres.

Free flowing mountain waters, unique and non-replaceable trout streams, are being threatened in several areas. Elsewhere we find persons concerned with this program pointing with pride to lowering water tables resulting from drainage which then creates more cropland. Is this conservation or exploitation? And in the Mississippi Flyway, hardest hit of all the waterfowl flyways, more federally subsidized drainage has taken place than in any other flyway and is still taking place. In the past 20 years over 40 million acres have been drained under the Agricultural Conservation Program with 68% of this taking place in the Mississippi Flyway States. This is continuing with over one million acres being drained under the program in 1960. A precious heritage shared by all is going down the drain. Well, what is the answer? There is no use in viewing with alarm unless we can make suggestions which, if followed, will permit us to point with pride.

At the beginning of my remarks I stated my thought that watershed planning and development was the way and the answer. The basic fact behind watershed development possibilities is that here complete control, planning, and development, without effect from outside factors is possible. This is of no avail if all resources are not considered. If some one practice is favored, particularly one destructive to existing or potential resources, the basic value of the watershed conservation theory and program is destroyed. The huge acreages now involved or in process of being involved with this program points to the possibilities and indeed, I know of no other way or other process through which complete conservation of our nation's material resources can be insured.

The very logic of the watershed approach is the basis of its acceptance by the people—of its support by many who are not directly concerned with the lands involved. They see the logic of taking our nation's surface parcel by parcel and working out within the confines of each parcel, without outside physical effects, the complete protection and development of our natural resources. Due to this logic the watershed program and its support stands upon a pinnacle of great strength. Great strength carries with it great responsibilities, and those responsible must consider conservation of all resources which the program affects. Great strength behind any public program is based upon public opinion, and disillusionment can change public opinion overnight, and the strength will fade away. Therefore, I urge those primarily responsible for these programs to take a new look at the situation. I urge that all resources be considered. If it is necessary to destroy some of the value in the process of meeting economic justification then justification simply does not exist. The fact that a dollar tag is difficult to place upon game and fish resources does not alter the fact that these are resources in short supply and facing an increasing demand. This is borne out by the report of the Outdoor Recreation Resources Review Commission.

Free and naturally flowing streams are also in short supply. May I suggest that the engineering abilities now supporting watershed programs be used in the field of either protecting existing streams or restoring destroyed ones to a natural condition. I also suggest that following this the absorption of rainfall be computed on the basis of what can be absolutely assured of being handled upon the land through individual farm conservation practices and that impoundments be planned to handle the margin which will not be taken care of through absorption upon the land or flowage through a stream in a natural condition.

I am sure that this would not meet present economic formulae in many cases. Where it does not, then the present formulae does not provide for complete conservation within a watershed as is generally, but falsely, contemplated. It may have been necessary at the beginning in the establishment of the watershed program to cut corners, to slight certain resources to take advantage of a locality's interest in some particular practice, but that day is passed. The very acreages involved in the watershed program show this. Those planning and guiding this program should be in a position to insist upon a most complete conservation program in each watershed, giving due consideration to all resources. Of course there will be times when some compromise is necessary, but the principles of complete conservation should be kept in mind, and if this is done, by and large, it will be placed into effect.

The watershed program is our last best hope to achieve true conservation of natural resources in this land of ours. It deserves the support of all. It also calls for a demand by all that through this program every effort be made to conserve and develop every possible natural resource—particularly those in short supply, i.e. water, natural flowing streams, fish and game.

TECHNICAL SESSIONS

Tuesday Morning—March 5

Chairman: KARL W. KENYON
Biologist, Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Seattle, Washington

Discussion Leader: H. DEAN FISHER
Scientist in Charge, Arctic Unit, Research Board of Canada, Montreal, Quebec

COASTAL AND MARINE RESOURCES

THE MANAGEMENT AND STATUS OF MARINE MAMMALS IN ALASKA

JAMES W. BROOKS
Department of Fish and Game, Juneau, Alaska

For more than a century and a half following Bering's discovery voyage to Alaska in 1741, none of man's endeavors in the North Pacific approached in prominence or importance his exploitation of marine mammals. Even before that time these animals were a dominant influence on the area, for without them Alaska's coastlines and islands would never have been able to support the relatively large Aleut and Eskimo populations which developed there.

Long and extensive unregulated exploitation which followed Bering's discovery greatly reduced the abundance of several species. Eventually restoration commenced, though it has often been slow and threatened with reversal. The importance of many of these animals is again increasing, and an understanding of their status and management needs is essential to continued conservation success.

Conservation efforts are blessed with one element of singular importance—sea mammals occupy a vast habitat which is not subject to easy change or alternative uses by man. In effect, their niches are reserved for them, an advantage seldom enjoyed by terrestrial animals. On the other hand, marine mammals range in international waters, which leads to difficult problems in promoting cooperation with foreign powers. Similarly, close cooperation must be established between State and Federal governments where mutual responsibilities are involved on refuges or the high seas.

Alaska assumed jurisdiction over, and responsibility for, many marine mammal species following the achievement of statehood in 1960. It is my intention here to provide a status report on these species, excluding the fur seals and large whales, which are the responsibility of the Federal Government by virtue of the existence of international treaties.

THE SEA OTTER

The original distribution of the sea otter (*Enhydra lutris*) included the coastal areas of the North Pacific from California to Northern Japan, with the probable center of abundance being the Aleutian Islands. The continuity of distribution was shattered as the animals were locally extirpated. The era of exploitation which commenced in 1741 did not end until protection was extended to relict pods in North America under the provisions of the 1911 Fur Seal Treaty. It should be noted that Russia imposed some conservation measures during her later years of Alaska occupancy but these were abandoned upon the United States' purchase of Alaska. Lensink (1959) estimates that at the low point of abundance, about 1911, the population numbered less than 500 animals. At the present time no sea otters are known to exist between the small colony off Monterey County, California, and the easternmost Alaska colony near Cape St. Elias, a two thousand mile span of former habitat.

Aerial surveys conducted by the Bureau of Sport Fisheries and Wildlife and on a smaller scale by the Alaska Department of Fish and Game revealed that sea otters have repopulated most of their former range in Alaska west of Cape St. Elias. Lensink (*op. cit.*) placed the total population at between 27,000 and 47,000 animals, while Kenyon (1961), on the basis of more recent and detailed data, estimates that there are between 20,000 and 30,000. It is clear that 50 years of complete protection have produced gratifying increases accompanied by dispersal to much former range. In certain areas, as the Rat Islands of the Western Aleutian Chain, the animals have undoubtedly reached the limit of habitat capacity and they may be approaching it elsewhere.

The favorable response of the sea otter to complete protection encouraged attention to their biology and management. Since World War II significant advances have been made in our knowledge of the animal's biology. Additionally, techniques for holding live animals were developed with the objective of effecting transplants to parts of their former range from which they had been extirpated. Kenyon (1960) has described in detail all efforts made to transplant sea otter in Alaska. With the possible exception of a 1959 transplant from Amchitka Island to the Pribilof Islands, such efforts have not been successful. It is believed, however, that know-how gained from past experiments will enhance the prospects for future success.

We hope that a cooperative State-Federal transplant program will be undertaken with the aim of re-establishing the animals in the Pribilof Islands, the Near Islands of the Western Aleutians, and Southeastern Alaska's Alexander Archipelago. In the latter area, unfortunately, a bounty on hair seals will no doubt cause the loss of some otters and may in fact preclude their existence in an otherwise suitable habitat.

Robert D. Jones, Jr. (1951) suggested a dozen years ago in a paper presented to this section of the North American Wildlife Conference that the time might not be far off when sea otter fur would again appear on the world's fur markets. I can report that that time is indeed near at hand. With permission of the Bureau of Sport Fisheries and Wildlife, the Alaska Department of Fish and Game is now taking experimental harvests of sea otter from the Aleutian Islands National Wildlife Refuge for the purpose of determining whether a commercial harvesting program is feasible. The value of sea otter pelts in former times is legendary, and one finds frequent reference to single pelts bringing $1,700 or even more. Fisher (1941) gives an excellent recapitulation of the early trading in these pelts. Originally the market for sea otter fur was in Asia and Europe where it was employed as trimming on men's garments. At present it has no established demand. We believe that its acceptance in the high fashion women's garment industry is a prerequisite to successful merchandising. Creating a new utilization and demand for the pelts will require careful and extensive promotion. The Alaska Department of Economic Development and Planning is initiating such a program.

Other problems connected with managing the sea otter as a commercial resource include the control of poaching once furs are again marketed, determination of appropriate harvest levels for various populations, methods of selecting animals of highest value (sea otter have a diffuse molt that seems to proceed to some extent throughout the year), methods of preparing pelts for marketing, and procedures for actually harvesting the animals.

We feel that the State must maintain complete control over harvesting operations because of the precise and fragile nature of such an enterprise. It is necessary too that complete agreement and coöperation be maintained with the Bureau of Sport Fisheries and Wildlife as most potentially harvestable populations are located in the Aleutian Islands Refuge. Then, too, poaching could probably not be controlled without the assistance of the Federal Government.

Last year we harvested 174 otters at Amchitka Island. We hope to take about 300 pelts at various times from different locations during 1963. We will not consider larger harvests until questions of market acceptance and value have been answered.

HAIR SEALS

The so-called hair seals in Alaskan waters include the harbor seal (*Phoca vitulina* sp.), ringed seal (*Pusa hispida* sp.), ribbon seal (*Histriophoca fasciata*), bearded seal (*Erignathus barbatus* sp.) and the northern elephant seal (*Mirounga angustirostris*). Of these, only the harbor seal ranges through Alaska's coastal area; the northern elephant seal is an occasional visitor to southern Alaska waters while the other seals are confined to the Bering Sea and arctic waters north of the Bering Straits.

The harbor seal far outnumbers all other seals in Alaska's coastal waters. It is strictly a fish eater, and because of this, has been widely condemned by commercial fishermen. We have found from examining large numbers of harbor seal stomachs that a variety of fish species including salmon are taken. Salmon, however, are nearly always removed from gill nets rather than being caught as free swimming fish. We have, therefore, concluded that harbor seals are harmless to our commercial fisheries except where salmon gill nets are employed. In these areas, they frequently destroy such large quantities of salmon that control is clearly warranted.

In keeping with American tradition, Alaskans long ago invoked the bounty system with the harbor seal as the main target. The present bounty is three dollars, though it has varied from $2.00 to $6.00 in the past. Since 1927, well over one million dollars has been paid for the destruction of about 420,000 seals, the bulk of which were harbor seals. It is clearly evident that the bounty system has done little more than keep the harbor seal population in a healthy state of productivity. It is generally felt in Alaska that the bounty program is a welfare measure and is justified on that basis.

The Department of Fish and Game has conducted intensive harbor seal control in three important gill net fisheries during the actual fishing season. In the past decade, more than 30,000 seals have been destroyed, mostly by a dynamite depth bombing technique. This program has been enconomically rewarding through reduction of seal depredations. But this huge removal of seals has had only local influence on their numbers, for herds of 1,000 or more individuals in adjacent areas have shown no decline. Localized depredation control involving harbor seals will be continued by the Department of Fish and Game as long as it is recognized as being economically sound. It is likely, too, that the bounty system will be continued for some time.

The ringed seal and bearded seal are mostly confined to the vicinity of the arctic ice, though some do spend the summer south of the Bering Straits. They are unknown east of the Alaska Peninsula and are even rare in Bristol Bay, just north of the Peninsula, except during the summer. They are primarily crustacean eaters, though the ringed seal does eat small fish. Certainly their role as predators on commercial fish must be completely discounted.

Both of these seals are extremely important to the Eskimos of arctic Alaska. To several thousand Alaskans, they constitute the staple food that allows survival. In addition the skins of the ringed seal are worth about $3.00 raw, and are much used for clothing. The bearded seal skin is valued at about $8.00 in the raw state and is used mainly as boat covering, boot soles, and line. The annual harvest of ringed seals is estimated at 8,000 to 10,000. Probably fewer than 1,000 bearded seals are taken annually. There is no evidence that harvests of this magnitude have any effect on seal abundance.

The Department of Fish and Game is conducting studies of the utilization, movements, and basic biology of these seals. No regulatory restrictions on harvests appear necessary at this time.

The ribbon seal is a relatively rare pelagic animal of the Northern Bering Sea. Small numbers are taken incidental to the hunting of other seals and walruses, and the skins of the males are much valued, being black with a cream colored stripe pattern over the back. The dispersed and scanty population of these seals is apparently characteristic of the species and not related to exploitation.

Northern elephant seals are reported periodically in southeastern Alaska. David Klein (*in litt.*) has provided me with two reliable records from the log book of Captain Walter Hofstad who observed one near Kuiu Island in Chatham Strait on September 7, 1955, and another in the same locality on May 7, 1957. Other verbal reports are heard occasionally. The animal is something of a curiosity, however, and has little signficance in Alaska.

THE PACIFIC WALRUS

The Pacific walrus (*Odobenus rosmarus divergens*) has been greatly reduced in abundance by humans in historic times. Francis H. Fay (1957) reconstructed from written records the history of this exploitation and concludes that during the 18th Century at least 200,000 animals must have existed. The population low of perhaps 40,000 animals probably occurred during the present century.

In the last decade, great progress has been made in gathering information about the life history, population status, and management of the walrus. Aerial surveys over the Bering Sea conducted by the Bureau of Sport Fisheries and Wildlife have been particularly valuable in providing more confident estimates of numbers than could be obtained by indirect means. It appears that the population may now include 70,000 or more animals (Kenyon, unpub. ms.).

Biological studies suggest a potential rate of increase of 12 or 13 per cent annually and this information permits us to judge the significance of harvests. Thus, it appears that 8,000 or 9,000 walruses could be taken annually from the present population without causing a decline. The Alaskan kill averages about 3,000 animals a year of which some 1,200 to 1,300 are retrieved while the remainder are lost through sinking. (The 1960 kill, however, was larger than usual, and approached 4,600 animals.) It appears, therefore, that an annual harvest by Siberians of much over 6,000 walruses would deplete the stocks. We hope it is much less than that. Fay (1957) citing Krypton, suggests that the Siberian annual harvest in the mid-1950's was 4,000 to 6,000 animals. Fay more recently advised me (*in litt.*) that he regards recent occurrences of walruses in long-vacant southern parts of their range as indicative of increasing numbers. From the evidence available, it does appear probable that the population is now increasing.

The Department of Fish and Game is continuing basic biological studies of the walrus. We are also attempting to refine and evaluate a tooth aging technique which could allow more confident analysis of reproductive and age characteristics as reflected by the harvest. We will continue to gather accurate records of size, distribution, and utilization of harvests.

Present management seeks to discourage the practice of ivory hunting. We prohibit the sale of raw ivory except under permit, and such permits are granted only to the extent necessary to allow a flow of ivory within the carving industry. In addition, a limit of five adult cows or sub-adults of either sex is imposed to divert effort toward the bulls. This regulation has effected a remarkable shift in the sex ratio of the harvest; at Diomede Island where cows ordinarily constituted the bulk of the harvest, 60 per cent of the take was males in 1962. Further advances that are obviously needed include development of less wasteful killing methods. Unfortunately, this is the type of change that is difficult to bring about for it strikes at an area where the hunters are not only satisfied with, but are proud of, their present performance.

POLAR BEAR

The distribution of the polar bear coincides with the Arctic ice pack which, adjacent to Alaska, extends south of the Bering Straits in winter and retreats northward to or beyond Point Barrow in the summer. Driven by currents and winds, the ice pack near Alaska is in constant motion, breaking up and causing the transitory formation of open-water leads. This situation creates conditions particularly suitable for seals, the principal food of polar bear. While tending to wander widely as well as moving passively with the ice, polar bears inevitably concentrate where seals are abundant. As compared with other parts of the arctic, Alaska seems to be favored with a plentiful stock of bears.

Until about 1948 Eskimos took practically the entire Alaska harvest of polar bears, utilizing them for subsistence and commercial purposes. Since that time bush pilots and guides have developed aerial hunting techniques that allow sportsmen to bag the animals with a relatively small expenditure of time. Aerial hunting for trophies now accounts for the bulk of the harvest.

Table 1 shows the estimated and known Alaskan take of polar bears from 1952 through 1962.

TABLE 1. THE ESTIMATED AND KNOWN HARVEST OF POLAR BEARS IN ALASKA FROM 1925 THROUGH 1962 ACCORDING TO HUNTER TYPE*

Year	Resident Hunter White	Resident Hunter Eskimo	Nonresident Hunter	Total Harvest
1925 through 1953	Very few	Majority	Few	117 (Average)
1954	?	?	?	100
1955	?	?	?	128
1956	?	?	?	135
1957	53	78	75	206
1958	19	40	69	128
1959	?	53	?	250
1960	?	62	?	162
1961	60	26	70	156
1962	96	12	85	193

*Data from (Olson, 1959), (Scott, et al., 1959), (Tovey, 1957), and unpublished data in Department of Fish and Game files.

While the polar bear harvest fluctuates widely from year to year (for example, 128 bears in 1958 compared to 250 in 1959) the average harvest has increased from 117 in the years prior to 1954 to 162 annually since that date. We believe, however, that this increase has little biological significance because it largely involves trophy bears, which are usually males. While Eskimo hunters are known to be non-selective and take about as many females as males, guided, nonresident trophy hunters demonstrate a high degree of selectivity for large bears and take at least 80 per cent males. The increasing over-all harvest is thus offset by the decreasing native harvest which formerly accounted for a large number of sows.

The practice of airplane hunting coupled with the declining take of bears by Eskimos has alarmed many conservationists who feel that use of aircraft is not only unsportsmanlike but is having a disastrous impact on the bear population. The question of sportsmanship involved in aerial hunting is beyond the scope of this paper. I can confidently say, however, that aerial hunting is not responsible to any significant degree for the decreasing bear harvest by Eskimo hunters, for there is little direct competition. Most polar bear hunting by Eskimos occurs prior to the first of March, while aircraft hunting is concentrated in the months of March and April. Furthermore, it appears that the Eskimos are experiencing a fairly rapid transition in their economies and way of life, with a lessening dependence on game resources for subsistence. Then, too, the taking of polar bears by the Eskimos no longer carries great and traditional prestige: much of this significance is lost by witnessing the ease with which white men are able to take bears. For these reasons, the decrease in Eskimo bear harvest is not believed to be a result of a decrease in the bear population.

The first effort to regulate the Alaska harvest of polar bears was a regulation imposed by the Secretary of the Interior in 1949 which restricted the yearly bag limit to two animals. In 1955 the bag limit for nonresidents of the territory was reduced to one animal and in 1957 this reduction was applied to residents and nonresidents alike. The taking of cubs or females accompanied by cubs was also prohibited at this time. In 1960 the Alaska Board of Fish and Game promulgated its first regulations and acted to retain former restrictions, while additionally closing the season on polar bears between May 1 and October 1 to preclude the development of boat hunting as practiced out of Norway. However, the Board did permit the taking of polar bears at any time for food purposes by residents of the Arctic. The following year (1961) a regulation was adopted requiring that all polar bear skins be presented to a representative of the Department of Fish and Game for sealing. This regulation provides the basis for our present management program in that it furnishes precise information on the number of bears taken, when, where and by whom they are taken and their size and sex. Unfortunately, it is not possible to age bears from examination of hides. We therefore hope to refine our regulations further and require that the skulls, which are ordinarily retained as trophies anyway, accompany the hides until the latter have been sealed. This measure will give us information on changes which may occur in the age composition of the harvest.

In attempting to evaluate the effects of the harvest on the bear population, data have been gathered for several years relating to the frequency of bear sightings by aircraft hunters. We think that this may serve as an indicator of changing abundance of the animals. Table 2 presents this information for the seven year period from 1956 through 1962. The availability of bears has remained remarkably constant with no detectable change at all during the past three years.

TABLE 2. POLAR BEAR OBSERVATIONS IN RELATION TO HOURS OF FLYING AS REPORTED BY AIRCRAFT HUNTERS

Year	No. Flying Hours	No. Bears Sighted	Bears Seen Per Hour
1956	84	33	0.4
1957	383	222	0.6
1958	185	201	1.1
1959	265	498	1.9
1960	164	179	1.0
1961	356	340	1.0
1962	313	304	1.0
Total	1,750	1,777	1.0

Because of the difficulties faced in censusing polar bears, it is probable that our management program for many years will be premised on information derived from the harvest. We believe that these harvest data may well reflect disturbances in the polar bear population that result from harvests in Siberia, Canada or elsewhere for it appears that we are dealing with one holarctic population.

THE STELLER SEA LION

Extensive aerial surveys reported by Mathieson (1959) and Kenyon and Rice (1961) suggest that Steller sea lions (*Eumetopias jubata*) in Alaska may number 150,000 to 300,000 individuals. With the exception of the Pribilof Islands population which was once greatly reduced in size (Kenyon, 1962) no serious inroads have ever been made in our sea lion stocks. These animals now probably approach the maximum in abundance possible in Alaska.

We have conducted some basic life history studies of the sea lion, but have not as yet published the results. Indications are, however, that reproductive rates are much lower than formerly supposed.

These studies will be intensified with the recent assignment of two biologists to marine research.

Being an abundant and conspicuous fish eater, this animal suffers much condemnation from commercial fishermen. However, from food habits investigations thus far carried out, we do not believe that they are serious predators on free swimming commercially important fish species. It is perfectly certain, however, that significant quantities of black cod, halibut and salmon are taken from fishing gear, mainly trolling lines and long lines. We have, therefore, been under heavy pressure to institute control measures against them.

Because the sea lion has potential value as a source of meat for human and animal consumption, efforts have been made to encourage interest in such commercial utilization. The Bureau of Commercial Fisheries subsidized an experimental harvest of sea lions in 1959 (Thorsteinson, 1961) and learned much about harvesting techniques and value of the products. The Arthur D. Little firm is currently making further studies of this problem under contract with the Bureau of Indian Affairs. At this time the prospects are discouraging that commercial harvests will prove feasible, and this situation makes it increasingly difficult to placate those who demand sea lion control.

In the near future, the state may undertake localized experimental sea lion control involving the destruction of pups on one or two rookeries. I do not anticipate the development of widespread control efforts, nor the imposition of bounties. We will continue efforts to promote beneficial utilization of this resource as the best ultimate management procedure.

THE BELUGA

The beluga (*Delphinapterus leucas*) is a toothed whale, seldom exceeding 15 feet in length, which is confined to arctic and subarctic waters. It is common along the coast of Alaska, west and north of Cook Inlet. We have counted as many as 800 in Bristol Bay river estuaries during the summer months, but have little basis for estimating total numbers. Much of the beluga population is migratory, moving from the Bering Sea into the Arctic Ocean during the spring and returning in the fall. It is apparent that summer dispersal in the Arctic Ocean extends along the arctic coasts of both Siberia and Canada.

These animals are highly esteemed by the Eskimos of northern Alaska, who hunt them for meat and oil. The annual harvest does not exceed three hundred animals and seems to have little or no influence on the population size. The animals are recognized to have certain negative values in that they are quite efficient predators on salmon in certain limited situations. Predation studies which I conducted during 1954 and 1955 (Brooks, 1955) demonstrated a direct loss to belugas of approximately three million seaward migrating red salmon in the Kvichak River estuary during a single year. Such findings did not, I am pleased to report, precipitate wholesale destruction of the belugas. We found that with a relatively small expenditure of time and money, most predation could be prevented by simply chasing or herding the animals out of the confines of the river estuary during a critical three-week period while the seaward migration of young salmon was in progress. Little attention has been directed toward the belugas since 1960, but our investigations and efforts to refine nonlethal methods of controlling predation will be renewed this year. We presently have no regulations protecting this animal aside from a prohibition against wanton waste.

SPECIAL CONSIDERATIONS

A matter of some importance to Alaska involves federal legislation, which as HR 7490 was passed by the House of Representatives in 1962. If enacted into law, this act would place the total responsibility in the Secretary of the Interior for the management of polar bear, walrus, and sea otter. While wishing to encourage federal participation in research, Alaska has objected strongly to losing management authority over resources which are vital to her people and interests. Although the major portion of the Alaskan harvest of polar bears and walruses is taken on the High Seas, the entire harvest returns to Alaska. Our regulations governing possession and transportation in the state have proven perfectly adequate to legally and actually impose controls on harvests. We hope that legislation, if adopted, will not cause abandonment of the present state management program which appears at this stage to be highly successful.

Another matter that needs clarification and agreement is the degree of state authority over game resources on National Wildlife Refuges. Extremely harmonious relations have prevailed so far, but it is only a matter of time before differences will arise concerning game management practices. Having never assented to federal legislative control over the vast refuge areas in Alaska introduces the question of whether the state possesses such rights. Whatever determination is made, however, will clearly not obviate the need for continuing understanding and cooperation. As Urban C. Nelson, of the Bureau of Sport Fisheries and Wildlife, expressed to me: "If we do what is best for the resources, we can't go far wrong."

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DISCUSSION

MR. FISHER: Thank you very much, Jim.

We are accustomed when hearing reports on marine mammals from most parts of the world to rather depressing pictures of overexploitation of rapidly producing stock, and this report is most encouraging in its indication of the overall excellent conditions in those species covered by the report.

The special significance of polar bears is a contentious one, as Mr. Brooks pointed out. It is one that we are interested in in Canada. I would imagine you wouldn't have to go very far from shore in this particular aircraft in the polar bear land before you arrived in Soviet waters.

What is the nature and the evidence of aircraft hunting near you? Do they land on the ice when they see a bear, shoot it, and remove the skin? Has this been a problem in international relations with the Soviet Union?

MR. BROOKS: Potentially, it is a problem with international implications. The average distance from the coast of Alaska of the bear kills made by nonresident hunters is 80 miles. Many of the guides fly over to and along the coast of Siberia and, as you may have heard last winter, they caused a scramble of Soviet jet fighter planes which spooked the guides out of the area for two days, but they wandered back in. So, an incident could occur at any time.

MR. CHARLES CALLISON [Assistant to the President of the National Audubon Society]: I would like to ask a question that hasn't been covered so far in Mr. Brooks' paper. How much may be reasonably estimated about the population of the polar bear in other parts of the Arctic besides Alaska? I want him to comment on that if he possibly could, and the other thing I want to comment on myself for the information of those who may not see some of the slick paper magazines and newspapers published in New York City and on the eastern coast. We have been struck by the increasing frequency of high-powered advertisements done in the style of Madison Avenue in New York City and the Madison Avenues of other cities of the world encouraging trophy hunters to fly to Scandinavian countries and there avail themselves of a polar bear trophy. If this sort of commercial promotion keeps up, it seems to us we may be getting in some trouble if the polar bear is not already in trouble.

MR. BROOKS: I think what I say about our opinions would probably apply to those of our Canadian and Scandinavian and Russian neighbors. We have very little knowledge of the total world stock of polar bears. Estimates have been made. I believe that a few years ago Scott, Kenyon, Buckley, and Olson got together and examined all information pertinent to this question and suggested in a paper given at this conference that there may be 17,000 polar bears in the Arctic. This estimate was largely based on the abundance of bears along the Alaskan coast on a unit-area basis, and then extrapolated around the Arctic basin. I didn't attempt extrapolation now, because I don't feel that it is legitimate to extrapolate out the data because it isn't sound to begin with. The thing that makes any attempt to determine the abundance of bears on a unit-area basis difficult is that in examining these and knowing something more about aircraft hunting, you find that it is common to track polar bears. Therefore, the number of bears seen while flying over a given area doesn't give you a representative sample of all the coastal area. You're on a bear track, and you are a lot more apt to see a bear while following a bear track than if you were simply flying at random across the area. Former estimates are based on this system, and they might be accurate, but we have very little confidence in them. All I can say is that the Canadians are keeping very good records of the harvest. The Russians state in their literature, as I mentioned, that their harvest has been down. The number of bears taken in Greenland and in the Scandinavian countries is known. The harvests, I think, are our best gauge to the overall status of the polar bear population. We have no indication in Alaska or in Canada that an increase in the intensity of exploitation is having any effect on the polar bear population. We have in Alaska a closed polar bear season during the summertime between the first of May and the first of October, deliberately to preclude the development of summertime hunting from ships like that practiced out of Norway. As Charlie mentioned, this ship hunting for sport has been practiced in the eastern Arctic and is becoming more common. We do not want that developed in Alaska. We have all we can do to keep track of the aircraft hunting.

MR. FISHER: I might just make one comment. Jim mentioned the harbor seal and the fact that there is the inevitable bounty on this animal in Alaska. I don't know if he mentioned it when he spoke, but in his paper is an opinion that I have shared for some time on the question of bounties, on harbor seals in any event, and that is it makes specially sure of maximum sustained productivity, a very healthy effect on the population. Recent tremendous improvements in adding techniques of treating hair seal skins is rapidly increasing the world demand for these skins. Two years ago in Beaver House at the Hudson Bay Company in London, England, at a fur seal auction, I saw harbor seal skins from bounty hunters on Prince Charles Island being auctioned off for as high as $63 a pelt for clean uncured skins. We may be in the rather different position of protecting these animals before long if this trend increases. A somewhat different situation as to the encouraging position of stocks mentioned by Jim exists in the Atlantic whales.

Although the one bright spot in the Pacific has been the very encouraging comeback under protection of the gray whale once thought, not long ago, to be near extinction, it is now present in substantial herds in the Pacific totalling many thousands that give many people great delight to see. With the continued decrease of stocks of Antarctic whales, in which the countries involved have a tremendous investment in the costly specialized fleets of ships and the International Whaling Convention—14 countries with a commission meeting regularly and reviewing the best scientific evidence available—it is inevitable that some of this vast capability will shortly look north, both in the Pacific and in the Atlantic. This next paper by Mr. Rice outlines current research on the Pacific coast whaling and whale research. It is encouraging to know that this increase is happening because the need for some basis of knowledge at hand before this vast capability looks north may be on hand.

PACIFIC COAST WHALING AND WHALE RESEARCH

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At the 25th North American Wildlife Conference in 1960, Richard M. Laws (1960) presented a paper on the problems of worldwide whale conservation, with particular emphasis on the Southern Hemisphere. Since that time, the Southern Hemisphere stocks of baleen whales have continued to decline at an accelerating rate, as was predicted by biologists. A drastic curtailment of the catch will be necessary to maintain the remnant stocks at even their present levels. Fleets of factory ships and catcher boats represent a capital investment of millions of dollars. If they can no longer operate at a profit in the Antarctic, some of them may turn to the North Pacific. We do not know how much exploitation the North Pacific whale stocks can withstand. It is appropriate now to look critically at the U.S. whaling industry and at our whale research program, so that we may anticipate future research and management needs.

WHALING IN THE UNITED STATES

There is not enough time to go into the long and fascinating history of whaling in the United States, and I must therefore restrict myself to active whaling operations. Whaling is conducted from three commercial whaling stations on the Pacific Coast; and by the Eskimos of the Alaskan villages of Barrow, Point Hope, and Wainright, who use aboriginal methods to take bowhead whales (*Balaena mysticetus*) and gray whales (*Eschrichtius gibbosus*). Only commercial whaling will be discussed here.

In 1956, the Del Monte Fishing Company opened a whaling station on San Francisco Bay at Point San Pablo, Richmond, California. It operated two catcher boats that year, and added a third to the fleet in 1957. In 1958, the Golden Gate Fishing Company opened another station, also on Point San Pablo, with one catcher boat. A second boat was added in 1959. From 1959 through 1962 all five catcher boats operated out of Point San Pablo. A third company, Bioproducts, Inc., of Warrenton, Oregon, was licensed as a whaling station in 1961. This firm engaged in whaling only as a sideline, and its one vessel took only four whales in 1961 and one in 1962.

These 3 shore stations on the Pacific Coast of the United States represent only a small proportion of the whaling effort in the North Pacific. Other nations operate 25 shore stations and 3 floating fac-

[1]In the absence of the author, this paper was read by Mr. Karl W. Kenyon.

tories, employing 77 catcher boats. These include 2 shore stations in the Ryukyu Islands, 18 in Japan, 4 in the Kurile Islands, and 1 on Vancouver Island. Japanese companies operate two floating factories (the *Kinjyo Maru* and the *Kyokuyo Maru*) in the Bering Sea and Aleutian area, and the Government of the U. S. S. R. operates one floating factory (the *Aleut*) in waters off Kamchatka.

Six species of whales are brought in more or less regularly to the U. S. whaling stations. These include four species of baleen whales—the blue (*Balaenoptera musculus*), the fin (*B. physalus*), the sei (*B. borealis*), and the humpback (*Megaptera novaeangliae*); and two species of toothed whales—the sperm (*Physeter macrocephalus*), and the giant bottlenose (*Berardius bairdi*). In addition, one killer whale (*Orcinus orca*) was taken recently. Complete catch statistics of the California stations for the years 1956-62 are presented in Table 1. The average annual catch on our west coast has been somewhat less than 300 whales; this amounts to less than 3 per cent of the total North Pacific catch, which included 10,694 whales in 1961 (the last season for which complete figures are presently available). This included 92 blue whales, 1,876 fin whales, 955 sei whales, 500 humpback whales, and 7,271 sperm whales. The catch has remained fairly stable in recent years.

The United States, along with most whaling nations, is a party to the 1946 International Convention for the Regulation of Whaling. Regulations provide that shore stations may take baleen whales for only six months out of each year, sperm whales for eight. From 1956 through 1959, the season for baleen whales on our west coast was from 1 May to 30 October. Beginning in 1960, it was advanced to the period from 16 April to 15 October. The season for sperm whales has been 1 April to 30 November each year since the stations opened. The international regulations also fix minimum size limits. For shore stations producing fresh meat to be utilized in the country of origin,

TABLE 1. NUMBER OF WHALES TAKEN BY THE TWO CALIFORNIA SHORE STATIONS, 1956-62

Year	Blue	Fin	Sei	Humpback	Sperm	Bottlenose	Total
1956	....	3	....	133	9	....	145
1957	....	22	1	199	14	1	237
1958	26	109	2	115	8	1	261
1959	5	108[a]	37[a]	140	17	2	309
1960	1	138	47	67	16	2	271
1961[b]	2	118	51	62	101	4	338
1962[b]	2	123	22	39	60	....	247[c]
Total	36	621	160	755	225	10	1,808

[a]These figures differ from those in the International Whaling Statistics, because two fin whales were erroneously reported as sei whales.
[b]The catch in Oregon was: 1961—2 humpbacks and 3 sperms; 1962—1 fin.
[c]Includes one killer whale.

these limits are 19.8 m. (65 ft.) on blue whales, 15.2 m (50 ft.) on fin whales and 10.7 m. (35 ft.) on sei, humpback, and sperm whales. It is forbidden to kill females accompanied by calves. Certain species—the gray, right, and bowhead whales—are completely protected from commercial whaling.

The methods used by the California whaling stations are basically the same as those employed by shore stations in other parts of the world. The vessels scout the area within about 230 km. (125 nautical miles) of the Golden Gate. When a "blow" is sighted, the whale is pursued and killed with a harpoon from a 90-mm. gun mounted on a platform on the bow. The head of the harpoon is a grenade, the explosion of which often kills the animal outright. California whalers have developed a unique harpoon head, consisting of an iron pipe about 8 cm. in diameter and 24 cm. long. The front end is beveled on the inside to form a sharp cutting edge. A metal disc, recessed several centimeters, plugs the front aperture and retains the black-powder charge. This head has two advantages over the standard pointed, cast-iron head: (1) it is much less likely to ricochet when it strikes obliquely; (2) it does not shatter and leave fragments in the meat which might damage the grinder.

After the whales are killed they are tied alongside the vessel, tail toward the bow, and are towed to the station. Sometimes several are towed together. They may be flagged and set adrift while the vessel continues to hunt. If the meat is to be saved, the animals must be flensed within 20 hours of death.

At the station, a chain or strap is secured around the whale's tail, against the base of the flukes, and a winch hauls the carcass up a slipway onto the flensing deck. Flensing follows the standard procedure originally developed by the Norwegians. The meat is cut into chunks and cooled in tanks of chilled salt water, and is then ground, packaged, and frozen. The blubber, viscera, and bones are chopped up in a rotary prebreaker. This machine was designed by the superintendent of one of the local whaling plants. The other California station has also installed one. These machines have greatly speeded up operations and reduced the need for manpower. Basically, they consist of a row of heavy, square, stationary, steel teeth which protrude upwards; immediately above and parallel to the teeth is a steel axle, which also bears a row of helically arranged teeth. As the axle rotates, the upper teeth successively sheer between the lower teeth. The bones, blubber, and viscera, are fed into the machine; when this material is engaged by the rotary teeth it is crushed and cut between the stationary teeth. An entire skull or vertebral column can be accommodated. A screw conveyor loads the ground material into a truck for hauling to the rendering plant.

Whale products used in the United States include meat, meal, whale oil (*i.e.*, baleen whale oil), and sperm oil. The Oregon station also produces condensed solubles. Fresh meat is the most important product of the California stations; baleen whale meat is used as an ingredient in canned pet food, and the meat of both sperm and baleen whales is used on fur farms for mink feed. Whale oil is used in the United States as a poultry feed supplement and in paint. Sperm oil has a wide variety of specialized industrial uses. Meal, a by-product of oil production, is used in poultry feed and as a fertilizer.

The value of California whale catch has varied annually from four hundred thousand to nine hundred thousand dollars (Table 2).

The catch of whales at the California stations has fluctuated over the past 7 seasons. There is a general upward trend (Fig. 1), but the average number of whales killed annually by each boat may be declining (Fig. 2). Analysis is difficult, because six species—especially fin, sei, humpback, and sperm—contribute to the total. Several factors besides the relative numbers of each species influence the catch composition, such as the relative ease of capture of the different species, and their average size and value, etc. Population trends from year to year are obscured by differences in the number of days of rough weather, and by variations in the movements of each species due to variations in the abundance of the preferred food species, which are influenced by changes in oceanographic conditions. Despite these complications, when the data in Figures 1 and 2 are analyzed against the background of other factors, several trends are apparent.

Humpback whales constituted 92 per cent of the catch in 1956, and have declined steadily to 16 per cent in 1962. Humpbacks are fairly large, heavy-bodied whales, and are high in meat yield. They are primarily a coastal species, and are relatively slow and easy to capture. Their preferred food is anchovies (*Engraulis mordax*). In 1956, large numbers of humpback whales could be found within 50

TABLE 2. PRODUCTION OF MEAT, MEAL, AND OIL BY THE CALIFORNIA WHALING STATIONS, 1956-62

[Quantities in metric tons; values in thousands of U. S. dollars]

Season	Meat Quantity	Meat Value	Meal Quantity	Meal Value	Whale oil Quantity	Whale oil Value	Sperm oil Quantity	Sperm oil Value	Total value
1956	614	102	697	92	941	166	39	7	366
1957	816	160	1,132	203	1,397	196	90	18	577
1958	1,612	319	1,747	269	1,409	213	41	6	808
1959	1,690	347	1,708	263	1,697	253	78	12	875
1960	1,821	363	1,350	135	1,367	165	77	9	672
1961	2,245	397	1,490	201	1,255	179	302	61	837
1962	1,952	367	1,304	160	923	120	241	57	704

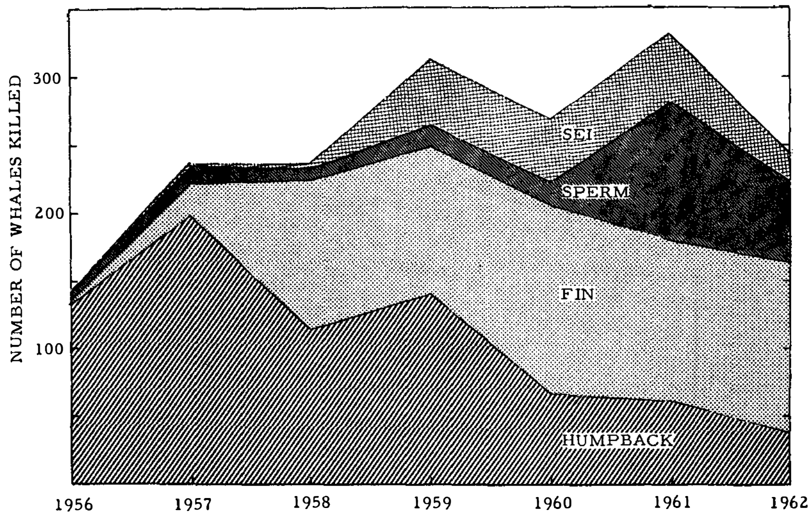

Figure 1. Variation in the catch of the four most important species of whales at the California shore stations from 1956 to 1962.

kilometers (30 miles) of the Golden Gate, so the catcher boats rarely ventured beyond the Farallon Islands. Today, few are seen here.

With the disappearance of the humpbacks, the catcher boats hunted farther to sea. Finback whales, second in size only to blue whales, are common in the waters 60 kilometers (35 miles) and more offshore. They feed chiefly on adult krill (*Euphausia pacifica*). Fin whales are more valuable than humpbacks, but their occurrence is less regular and they are swifter and harder to catch. The weather is more often bad offshore, and the longer tows reduce the time available for hunting. These factors make it more urgent to get the carcasses back to the plant while the meat is still fresh. Since 1958, fin whales have been the most important species in the catch. There is no indication that the stock is declining.

Sei whales, like fin whales, are usually found far offshore. They are considerably smaller than fin whales, though a sei whale yields much more meat than a young fin whale of equal length. Sei whales are present in California waters from July to October. They feed on immature krill, anchovies, sauries (*Cololabis saira*), sardines (*Sardinops sagax*) and copepods (*Calanus sp.*). Probably because of their more varied diet, they often remain in an area when lack of feed causes fin whales to leave. With the shift in hunting emphasis from humpback to fin whales, the sei whale catch has correspondingly increased. The sei whale population may be underexploited.

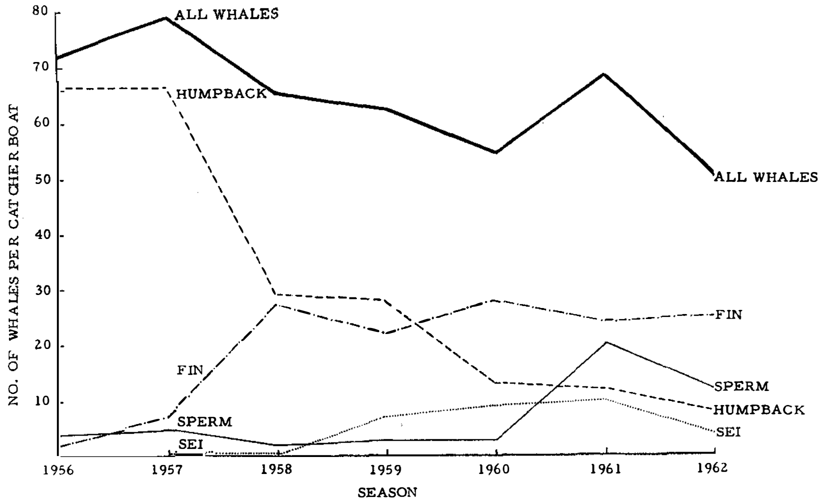

Figure 2. Variations in the total number of whales, and in the number of the four most important species, caught per boat at the California shore stations from 1956 to 1962.

Sperm whales were largely neglected during the first 5 years of modern California whaling, because there is little demand for their black, oily meat. In 1961, however, sperm whales were more abundant than previously, seemingly because of a greater abundance of the large squid, *Moroteuthis robusta,* their most important food. Female sperm whales usually remain in warmer waters, but several schools appeared off the California coast that year. Prices for sperm oil were high, and there was an increased market for sperm whale meat. The two stations killed over one hundred sperms that year, and in 1962 the catch of sperms remained high. In this polygynous species, few females exceed the legal minimum size of 10.7 m. (35 ft.), while males may grow to 17 m. (56 ft.); therefore the catch is largely males. For this reason, local whaling can have little effect on the breeding potential of the stock.

Blue whales are the largest of whales. A few usually appear off California in late September and October. They feed exclusively on krill. Only in 1958 were they numerous enough to demand the exclusive attention of the whalers for about 2 weeks.

Giant bottlenose whales, the largest of the beaked whales, are frequently seen. They are barely large enough, however, to be worth capturing and are taken only when other species are not available. For commercial purposes their meat and oil is considered the same as that of sperm whales.

THE U. S. WHALE RESEARCH PROGRAM

In 1958 the Marine Mammal Biological Laboratory of the U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries, located in Seattle, Washington, initiated a research program on the commercially important species of whales. Prior to this, the Service's whale research centered primarily on the protected gray whale. Studies of the gray whale have continued, and studies of the bowhead whale in Arctic Alaska are also underway. Most of the research effort is now devoted to the commercial species. This is the only aspect of the present program I will discuss. The objectives of the research are to provide the biological facts necessary for sound management. We must answer the following broad questions: (1) What is the basic life history of each species—especially, its breeding habits and reproductive rate, its age at sexual maturity, its food habits, its parasites, and diseases? (2) What are the geographical limits of each particular stock, what are its migration routes, and to what extent does it intermingle with neighboring stocks? (3) What is the size of each stock, what are its population parameters, and what is its maximum sustainable yield?

The answers to these questions are difficult to get, because cetaceans are large, wide ranging, and elusive, and ships of adequate size to pursue them are expensive to operate. Much of our knowledge must be based on indirect evidence rather than on direct observations. We have four methods for obtaining data on the larger whales: (1) examination of the animals killed in commercial operations; (2) analysis of the statistics of the commercial catches. (3) data from the recovery of marked whales; and (4) observations of live animals at sea. Unfortunately, the larger whales cannot be kept in captivity, though some of the smaller species of cetaceans have been studied in oceanaria. Bottlenose dolphins have been maintained through several generations at Marineland, Florida, and have provided data which are useful in interpreting life history data on the larger species. To date, our research program has concentrated on the first of these approaches.

Since the 1959 season, we have examined the majority of whales taken by the two California stations. Routinely, the ear plugs are collected for age determination, and the ovaries, uterus, fetuses, mammary glands, and testes are examined to determine the reproductive status of the animals. Data on stomach contents, blubber thickness, ectoparasites, endoparasites, and extent of fusion of the vertebral epiphyses are recorded. These have provided a basic framework of life history data on the species and stocks which our stations are harvesting. Compared with the extensive data gathered by whale biologists in other parts of the world—particularly the Antarctic and the western North Pacific—it has revealed many similarities, as well as some significant differences. It also provides direct evidence on age composition of the catch.

Certain morphological and physiological features of whales observable at the stations—such as size at maturity, body proportions, blood types, and frequency distribution of color phases, have provided evidence which suggests that the North Pacific populations of each species may be divided into several discrete stocks. Nevertheless, marking large numbers of whales is the only way to obtain direct evidence on their migrations, and the degree of intermingling between populations inhabiting different geographical areas. The standard whale mark, developed 30 years ago by the British Discovery Investigations, has proved quite successful. Designed to be fired from a 12-gauge, open-bore shotgun, it consists of a stainless steel tube 23 cm. long, with a lead point. The mark is fired into the epaxial muscles of the whale's back. Some marks have been recovered in good condition after 25 years. Biologists of the Japanese Whales Research Institute initiated an extensive whale marketing program in the North Pacific in 1949. To date they have effectively marked 3,443 whales of seven species; 249 have been recovered. Soviet biologists have effectively marked about 500 whales; data of recoveries of Soviet marks are not available. The Japanese and Soviet marking in the North Pacific has been done exclusively west of the 180th meridian, except for some Japanese marking in the eastern Aleutian and Kodiak area. From these data a broad picture of the patterns of movement is beginning to emerge (Fujino, 1960). Unfortunately, it is only half a picture, for in the eastern North Pacific only 36 whales have been effectively marked—20 by Canada and 16 by the United States. None of these has been recovered, but one Japanese mark has been recovered off Vancouver Island.

The long-distance movements of whales, revealed by marking programs, have shown the need for international cooperation in whale research. Research in the North Pacific has until now been conducted independently by the Japanese, Soviet, Canadian, and U. S. Governments. An important step was taken by the International Whaling Commission at its 14th Annual Meeting in London in June 1962. The Commission was alarmed about the prospects for North Pacific whale stocks, now threatened with increased exploitation. At the suggestion of Remington Kellogg, the U. S. Commissioner, the Commission appointed a committee consisting of one biologist from each of the four nations concerned—Canada, Japan, United States, and U. S. S. R. They instructed the committee to coordinate and review past and future research efforts in the North Pacific, and to advise the Commission on necessary management regulations.

At our first Committee meeting, a comprehensive review of whale marking accentuated the urgency of undertaking large-scale markings in the eastern North Pacific, particularly on the wintering grounds in the southeast. For several years, the U. S. Bureau of Commercial Fisheries has had plans for such a program. We made the first exploratory whale marking cruise in the waters off southern California and Baja California in November 1962, and will put in operation a realistic marking program as soon as possible.

Perhaps we have learned something from the tragic decline of the Antarctic whaling industry. Token regulations, tailored to suit the short-term convenience of the industry, will not save the whales, and when the whales are gone the industry will die with them. The industry and the governments involved are at last beginning to realize—we hope not too late—that each species and each stock of whales must be assessed and managed individually, that many more facts must be known before these assessments can be made, and that it is going to cost a lot of money to get these facts. Fortunately, a good start has been made by the Japanese and Soviet whale research organizations. If the other nations whaling in the North Pacific will cooperate in an adequate research program, there is still time to show that we can manage whale stocks on a sustained yield basis. We must decide soon whether we want those who come after us to suffer from our prodigality or to profit from our wisdom

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DISCUSSION

MR. IMES: In view of the fact that both the United States and Canada take a very low percentage of the total take of whales in the north Pacific, are they not in a rather awkward position to negotiate with Japan and Russia on some conservation methods?

MR. KENYON: Of course, I am not the whale man, and I can only speak in generalities. We don't, of course, know what our future needs might be, and since the high seas' resources are available to all nations of the north Pacific, we must consider we are to undertake the most thoughtful negotiation for conservation of these wide-ranging marine resources so that our future needs would not be jeopardized at any time.

DISEASE IN MARINE POPULATIONS

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The possible importance of disease in marine populations of commercial significance has not been adequately explored. Only in recent years has more than sporadic attention been given to diseases of marine animals, and even now this attention is often restricted to periods of disease outbreak in a particular species. The value of marine disease investigations has been pointed out by Oppenheimer (1953), Oppenheimer and Kesteven (1953) and Mackin (1959), and it is evident that to derive maximum continuing benefits from the sea we must understand all aspects of the biological systems that underlie the harvest of marine products. Disease obviously constitutes one determinant of abundance.

Research on diseases and parasites of marine organisms has been carried on in several laboratories, including the Bureau of Commercial Fisheries Biological Laboratory at Boothbay Harbor, Maine. Emphasis at this laboratory has been on diseases and mortalities of Atlantic herring, (Scattergood, 1948; Sindermann and Scattergood, 1954; Sindermann, 1958), although other species such as redfish, smelts, oysters, snails, and lobsters have received attention (Sindermann, 1961b; Sindermann and Farrin, 1962). The present paper, based on published and unpublished results of our research and on published research of other laboratories concerned with disease in marine populations of the western North Atlantic, is designed to present evidence available to support the following general statements:

1. Disease is related to changes in abundance of marine organisms.
2. Disease outbreaks may be influenced by several factors, including changes in susceptibility of the host population.
3. Disease outbreaks in one species may have pronounced negative or positive effects on other species.
4. Some disease problems in the sea are amenable to solution.

EPIZOOTICS IN MARINE SPECIES

Most available information concerns epizootics—widespread or rapidly spreading disease outbreaks—which have variable effects on susceptible species. Some outbreaks have been severe enough to result in local extinctions, while others have had only transient effects on population size. Epizootics may vary in intensity in different species, for different pathogens, in different geographic areas or at different times. The interactions of variables such as susceptibility of the host population, virulence and infectivity of the pathogen, effectiveness of transmission, and physical factors in the environment result in the dynamic changes in host-parasite relationship that we call an epizootic.

Possibly the most severe marine epizootic for which scientific information is available occurred in the late 1930's in velvet sponges and other sponges of the Gulf of Mexico (Galtsoff, 1940; Smith, 1941). Galtsoff reported that a fungus pathogen was responsible, but did not identify it. The outbreak led to extinction of velvet sponges in many areas of former abundance, and even today the populations of velvet sponges in parts of the Gulf have not recovered. Approaching the sponge epizootic in severity were mortalities of oysters on

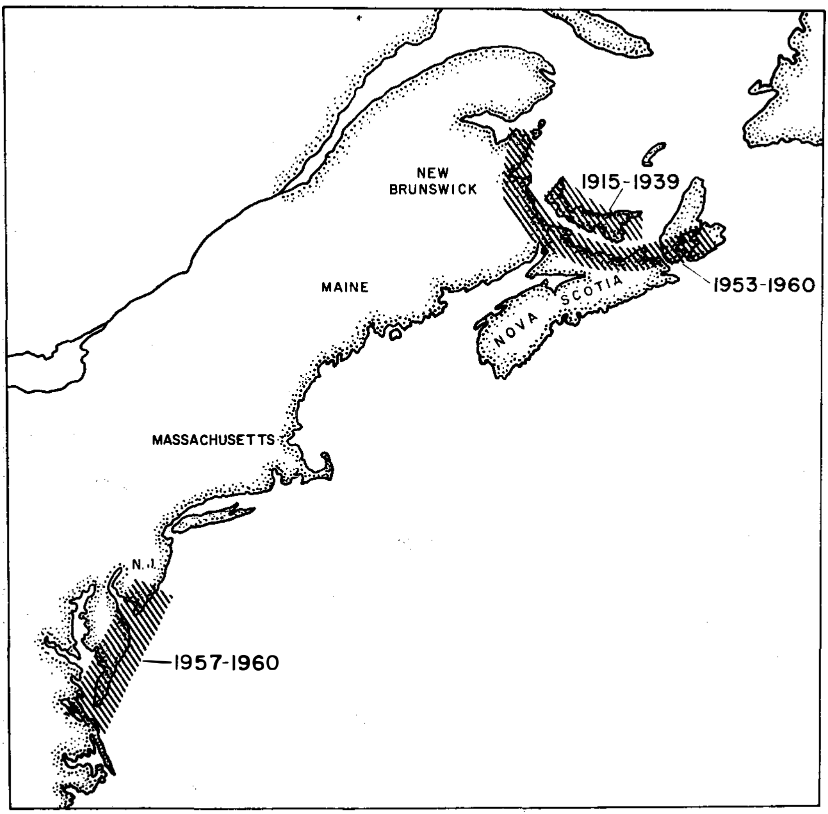

Figure 1. Areas of oyster mortalities on the east coast of North America.

Prince Edward Island beginning in 1915 (Needler, 1947), and more recently on the northern New Brunswick coast and in Delaware Bay (Fig. 1.) . Mortalities in these areas exceeded 90 per cent, and spat derived from survivors were also decimated for a number of years. Although the causative agent was not determined, resistance was apparently developed in Prince Edward Island oyster stocks (Logie, 1956), but 10 to 15 years of apparently severe natural selection were required. Mortalities of oysters transplanted to the island from other areas many years after the epizootic demonstrated that the causative agent was still present (Logie, 1956, 1957; Drinnan and Medcof, 1961).

Of relatively moderate severity have been periodic outbreaks of a disease of Atlantic herring caused by the fungus *Ichthyosporidium hoferi.* Such outbreaks in western North Atlantic herring have been reported since 1898 (Cox, 1916; Fish, 1934; Scattergood, 1948; Leim, 1955) ; the most recent occurred in the Gulf of Saint Lawrence in 1954-55. The disease is systemic, with massive tissue invasion focusing

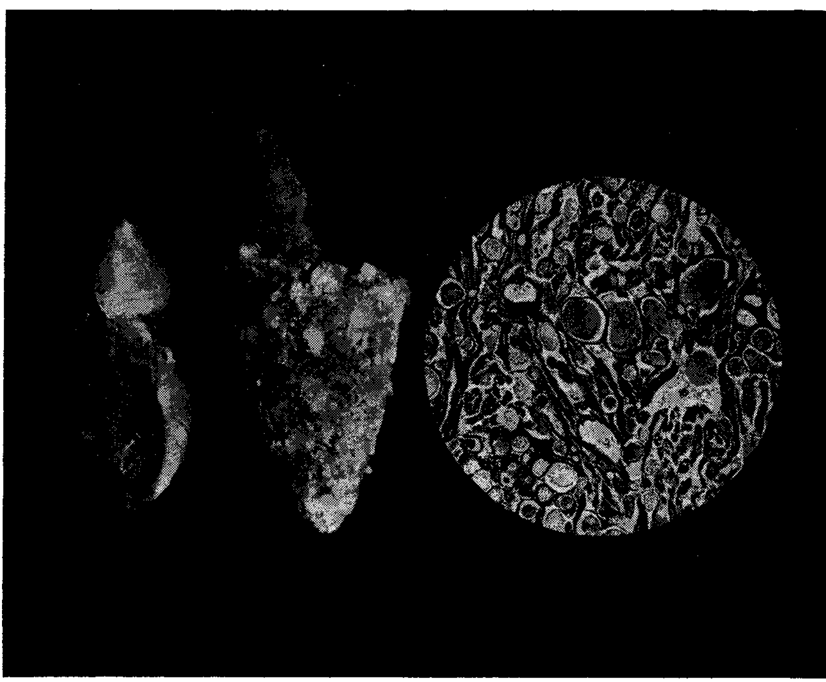

Figure 2. Normal (left) and fungus-infected herring hearts, with photomicrograph showing massive tissue invasion and disorganization.

in the heart (Fig. 2). Acute infection results in partial decay of the fish even before it dies. Mortalities due to this disease extended along hundreds of miles of Gulf of Saint Lawrence coastline in 1954 and 1955. An estimated one-half of the herring population in the Gulf was killed by the disease in those two years, and the reduction in landings since has supported our original estimate (Fig. 3). The disease decimated adult age groups and affected immature fish, but the high proportion of recruit spawners in 1960 and 1961—when herring spawned after the outbreak first entered the fishery—suggested that reduction in size of spawning stocks had not seriously

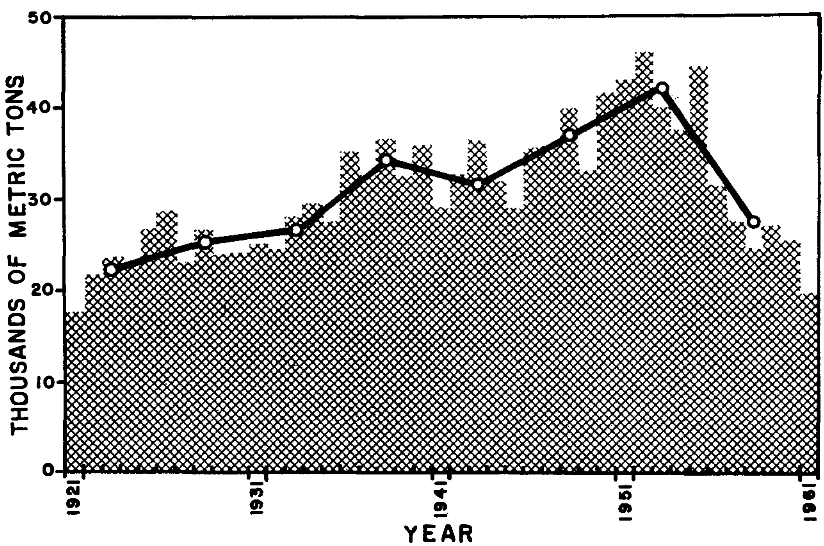

Figure 3. Gulf of Saint Lawrence herring landings 1921 through 1961, with five-year moving averages.

affected the size of year classes spawned after mortalities had ceased. The apparent periodic nature of outbreaks—14 to 25 years between peaks (Fig. 4)—indicates at best only transient increase in resistance of herring populations to the disease. This hypothesis is supported by the relatively low incidence of infections (27 per cent average at the epizootic peak—which constitutes relatively low selection pressure); by the fact that the most recent of four outbreaks in the Gulf of Saint Lawrence was at least as severe as the first; by determination of mortality rates during experimental epizootics in laboratory populations (Sindermann, 1958); and by experimental findings of individual variations in susceptibility to the disease.

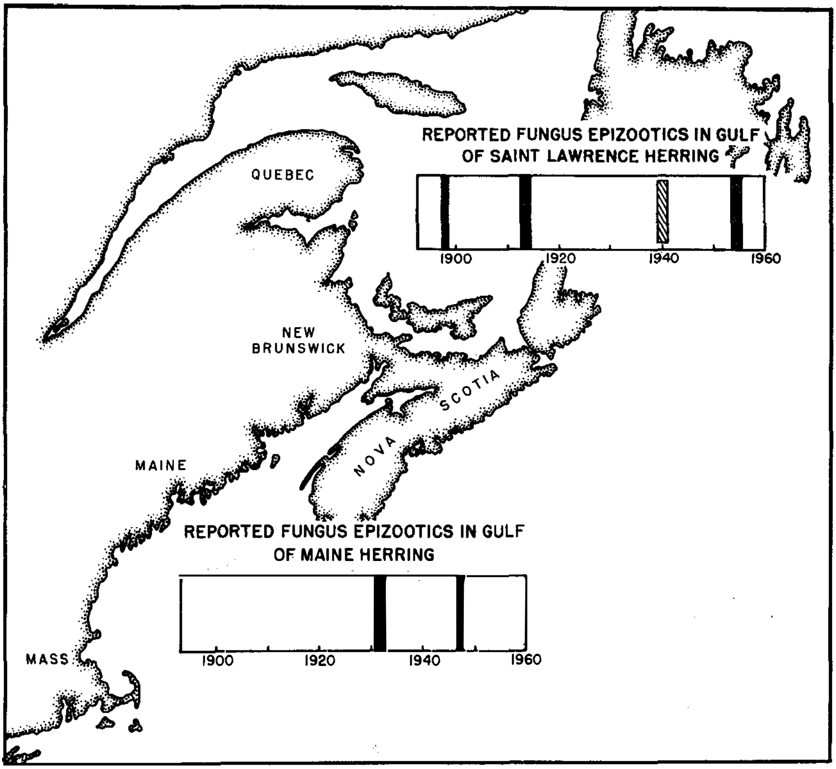

Figure 4. Reported fungus disease outbreaks in herring of the western North Atlantic. The Gulf of Saint Lawrence epizootic which occurred about 1940 was not recorded in scientific literature, and is included here on the strength of verbal reports from fishermen and other residents of the area. Such descriptions of the outbreak suggest that it was less severe than the 1954-55 epizootic.

Marine diseases with slight impact on abundance of a species are easier to find. An example is the protozoan disease of immature Atlantic herring caused by *Kudoa clupeidae,* a myxosporidian that produces intramuscular cysts (Sindermann, 1957, 1961a). The disease is acquired only in the early months of life, and symptoms disappear by the end of the third year of life. All degrees of infection may be found, but even heavily infected fish are present in schools containing mostly uninfected individuals. No differential mortality of infected herring occurred in laboratory experiments (Sindermann, 1957) and percentage of heavy infections remained unchanged in natural populations between the first and second years of life—an unlikely situation if differential mortality of heavily infected individuals occurred. Unobserved mortality could occur in the early invasive stage of the disease, however.

These few examples illustrate the range of disease effects on marine species—from one extreme of virulent, widespread disease with extensive mortalities and local extinctions, to the other extreme of low endemicity and slight pathogenicity, with little or no mortality directly attributable to the disease.

MEDIATING FACTORS IN MARINE DISEASE OUTBREAKS

Epizootic disease may be influenced by a number of often interacting factors, including:

1. *A population explosion of an introduced pathogen*—one to which the host species is susceptible and with which it has had little or no previous contact. Organisms in this category may be responsible for the severe oyster mortalities on our east coast—or the sponge mortalities off Florida. Also, such an epizootic in one species may result in an outbreak in other susceptible species occupying the same area. Sufficient infection pressure may be created to affect species less susceptible to the pathogen.

2. *Changes in the physical environment of the host population.* Effects of physical factors on disease outbreaks are difficult to determine in the marine environment, but have been clearly shown in fresh-water fish hatcheries, where furunculosis and other disease outbreaks have been influenced by temperature and chemical changes in the surrounding medium due to crowding (Davis, 1953; Snieszko, 1954, 1957, 1958). Disease susceptibility can be affected by such environmental variables as temperature, acting on antibody production; or availability of food, affecting the physiological condition of the host. Behavioral responses to seasonal environmental changes, such as major migrations, spawning, and inshore or offshore movements, could influence the spread of disease in a marine population. During the 1954-55 fungus disease outbreak in Gulf of Saint Lawrence herring, mortalities reached a peak in late spring, about one month after inshore spawning migration. Disease incidence was very low when fish first appeared on the coast in late April, and infections were probably acquired from spores overwintering in inshore sediments. Experimentally mortalities were produced in the same time interval (one month) following exposure to fungus spores.

Environmental factors can also operate more directly, such as temperature or salinity influencing the reproductive rate and infectivity of pathogens. In oyster mortality studies, salinities below about 15 parts per thousand retarded the development of lethal infection levels of *Dermocystidium marinum* (Ray, 1954; Ray and Chandler, 1955). Mortalities caused by fungus were significantly higher in oysters maintained in higher salinities. Lower mortalities from this disease and decreased numbers of pathogens in live oysters were also noted during the cold months of the year. Mackin (1953) concluded that lower winter mortality resulted from decreased metabolic activity of *Dermocystidium.*

3. *Changes in virulence and infectivity of a pathogen already present in enzootic form in a population.* Some genetic change in the pathogen may drastically upset a previously existing relatively stable equilibrium situation with the host. Although no documentation exists in fishery literature, we have examples of this in the history of great human epidemics.

4. *Changes in effectiveness of transmission of the pathogen.* With fish as well as other animals, the development of epizootics may be influenced by relative effectiveness of transfer of the disease organism from one susceptible host to another. Transmission may be enhanced by high population densities of susceptibles in the early phases of an outbreak, or retarded by low densities of susceptibles in the later phases. Immigration of susceptibles into a population or addition of susceptibles by reproduction can also act to enhance transfer of the pathogen.

5. *Changes in susceptibility of the host population to an enzootic disease.* During a period of low disease incidence the numbers of susceptibles could be increased, since there is little selection pressure against susceptibility. A critical point is reached where the pathogen, always present in the population, begins to spread. Incidence and infection pressure increase as contacts between susceptibles and pathogens are enhanced. Incidence reaches a maximum during the epizootic peak and then decreases rapidly as susceptibles become relatively rare and opportunity for effective contact of susceptible and pathogen decreases.

Although other factors such as population density or changes in the physical environment may be important, fluctuations in susceptibility could account for the changes in incidence and intensity of infections (Fig. 5), and the periodic outbreaks of disease in Atlantic herring. From observations made before, during and after the three most recent outbreaks—1931, 1947 and 1954—the general sequence of events that has emerged includes a long enzootic phase of very low disease incidence, several years of rapidly increasing incidence, the epizootic peak, and several years of rapidly declining incidence, returning to the enzootic condition. The 1947 outbreak in Gulf of Maine herring occurred during a time of low incidence in the Gulf of

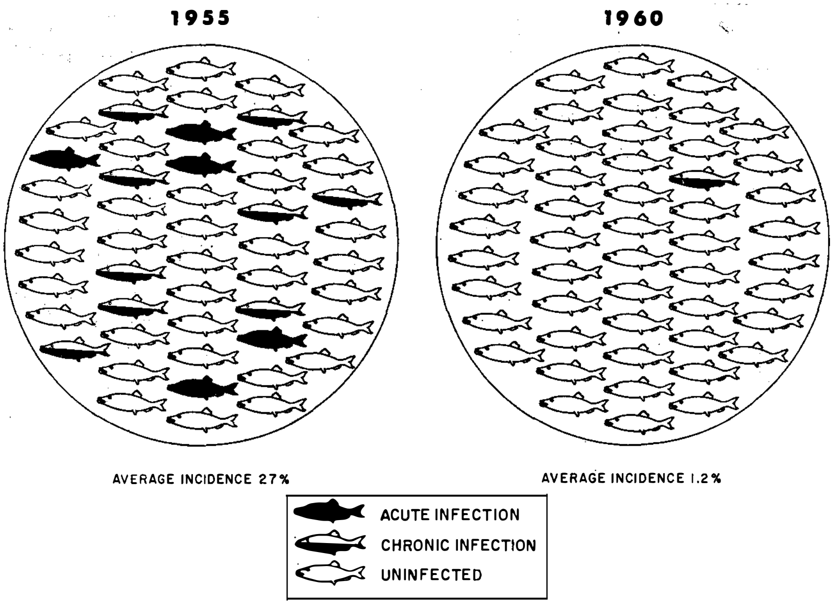

Figure 5. Relative frequencies of infected individuals in samples from Gulf of Saint Lawrence herring populations taken in an epizootic year (1955) and a post-epizootic year (1960).

Saint Lawrence, while the 1954 outbreak in Gulf of Saint Lawrence herring occurred when incidence was low in the Gulf of Maine. Continuing examinations for incidences of particular diseases in marine species have rarely been made. Periods for other diseases in other species could exist, but some may be much longer, so that two outbreaks of the same disease may not have occurred during the time when scientific study would have been carried out. Also, there seems to be a curious, and possibly more than coincidental, synchronization of outbreaks in different species due to different and unrelated pathogens. The underlying reasons, extrinsic or intrinsic to the species concerned, are obscure, but major outbreaks in several species have often occurred simultaneously. Prince Edward Island oyster mortalities in 1915, caused by an unknown pathogen, coincided with a fungus disease outbreak in herring; wasting disease of eelgrass (Renn 1934; Cottam, 1935) on the East Coast in the early 1930's coincided with a fungus disease outbreak in immature herring of the Gulf of Maine; lobster "red tail" disease outbreak in the Gulf of Maine, caused by a bacterium (Getchell, 1949), coincided with the 1947 fungus outbreak in herring of that gulf; and New Brunswick oyster mortalities of 1955 coincided with the most recent fungus epizootic in herring of the Gulf of Saint Lawrence. Each outbreak or mortality was severe enough to warrant attention by itself, and could not have been noticed merely because of increased awareness of disease at the time.

RELATIONSHIP OF DISEASE TO ABUNDANCE OF MARINE SPECIES

In the scientific literature there are several reports which definitely associate epizootic disease and mass mortalities with changes in abundance of marine species. The best evidence is found in the studies of herring fungus outbreaks. Cox (1916) reporting on the 1915 Gulf of Saint Lawrence outbreak, made this statement: "The herring fishery was reduced for several years following the outbreak." Similarly, herring landings in the Gulf of Saint Lawrence were reduced sharply following the most recent outbreak (1954-1955). Landings declined to slightly over half their previous level in the years immediately following the epizootic (Sindermann, 1958). The two most recent fungus outbreaks—the only ones for which we have adequate statistics from the fishery—occurred at times of herring abundance, as indicated by landing figures and general observations. Considering only two outbreaks, a relationship between epizootics and abundance might be coincidental, except for the obvious effect of disease on abundance of Gulf of Saint Lawrence herring in the late 1950's. Environmental factors other than disease undoubtedly influence abundance of herring, and an alternative explanation for the recent decline in the Newfoundland fishery was proposed by Olsen (1961). His explanation implicated a change in spawning habits, but failed to mention the extensive mass mortalities throughout the Gulf of Saint Lawrence, including the coast of Newfoundland, during the period 1954-1955.

Other evidence for causality of disease in population abundance changes can be seen in the Prince Edward Island oyster fishery following the 1914-15 outbreaks, the northern New Brunswick oyster fishery after 1955, and the Delaware Bay oyster fishery after 1958. In each area mortalities exceeded 90 per cent and persisted for several years. A weakness in this evidence is that a specific pathogen has not yet been related to mortalities, although a haplosporidian parasite has been implicated and the mortalities followed comparable patterns in the different areas. The effect, though, was clearly seen for each oyster growing area in the drastic slump in annual production that followed mortalities.

Apart from the conspicuous and sometimes catastrophic effects of epizootics on abundance of marine species, "low-level" or background disease effects may result in less conspicuous but not unimportant subtraction of individuals. Disease may be an important cause of mortality by weakening and disorienting infected fish, reducing their ability to survive changes in the physical environment and to escape predators; by making infected fish more conspicuous; or by altering their behavior patterns in ways that make them more vulnerable to predation. In our herring disease studies we have noted that fish with bacterial infections often exhibit characteristic and easily visible white patches near the tail (Fig. 6). Herring with fungus disease aggregate differentially in deeper water, and samples of immature herring from bottom trawls in inshore areas contain a higher frequency of abnormal fish than do samples taken with conventional surface gear in the same areas (Sindermann, unpublished observations). Among marine invertebrates, intertidal snails parasitized by larval trematodes do not participate in seasonal migrations to the same extent as normal individuals (Sindermann, 1960, 1961d). This has the effect of immobilizing diseased snails in the unfavorable high tide zone environment during winter months.

Disease may reduce the reproductive capacity of marine populations. Larval trematode invasion of marine snails such as the commercial periwinkle *Littorina littorea* causes sterility (Sindermann and Farrin, 1962). In inshore areas where such parasites are common, a significant percentage of individuals may thus be rendered non-reproductive. Gonad destruction has also been reported in crabs

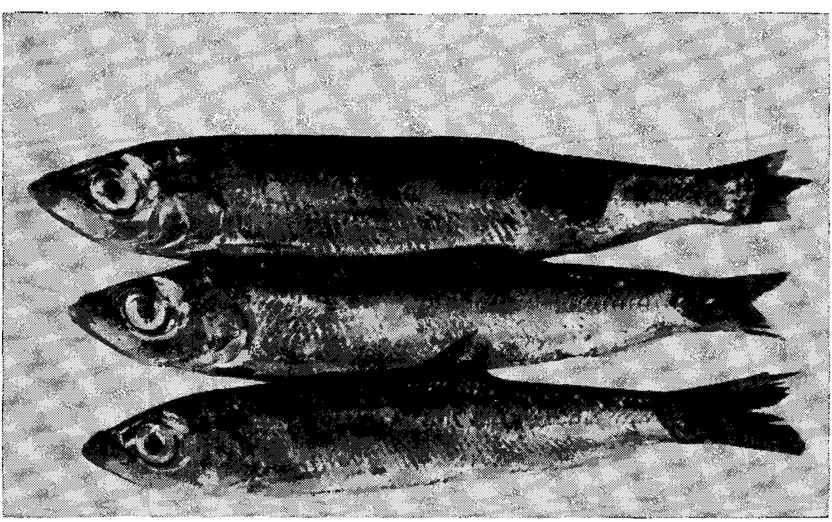

Figure 6. Symptoms of "tail rot" in fish dead of bacteremia about five days from onset of symptoms.

as an outcome of parasitization by sacculinid copepods (Reinhard, 1942). Among the fishes, parasitic castration has been reported in European sardines (Pinto, 1956) by a sporozoan (*Eimeria sardinae*). The same parasite has been observed in male herring from the western North Atlantic (Sindermann, 1961c). Mechanical interference with discharge of sex products may result from massive infections of smelt by a microsporidian parasite, *Glugea hertwigi.* Visceral cysts containing spores may in heavy infections occlude the vent and occupy much of the posterior part of the body cavity (Haley, 1953; Sindermann, unpublished observations).

Diseases and parasites may also exert effects on mortality rate by slow continuous attrition. *Dermocystidium marinum,* a fungus parasite of oysters, often appears to act in this way (Ray, 1954; Ray and Chandler, 1955; Andrews and Hewatt, 1957), as does *Cryptocotyle lingua,* a larval trematode parasite of herring and other inshore marine fish.

EFFECTS OF DISEASE OUTBREAKS ON OTHER SPECIES

An epizootic in one marine species may have pronounced negative or positive effects on related or associated species. The presence of great numbers of a pathogen during an epizootic may create sufficient infection pressure so that members of other species with less susceptibility to the disease organism may become infected. The presence of dying or disabled infected individuals may temporarily increase the food supply for predators or scavengers, resulting in accelerated growth and increased weight of such species. Evidence for such negative and positive effects of an epizootic in one fish species on other species was obtained from the fungus outbreak in Gulf of Saint Lawrence herring already mentioned above. Alewives, which seem less susceptible as a species to the fungus pathogen, (Sindermann and Scattergood, 1954) acquired infections and were killed in sufficient numbers to be observed. We examined one mass mortality at Dalhousie, New Brunswick in 1955, and others were reported by fishery officers and fishermen. Mackerel were also found to be heavily infected by the pathogen during the same period, and mortalities were observed. Cod, on the other hand, did not acquire infections, but fed on infected and dying herring to such an extent that their growth rate(indicated by scale growth zones) exceeded anything previously known (Martin, 1956). Cod landings almost doubled during the period immediately following the herring epizootic, due almost entirely to increased weight of individual fish landed, rather than to increased numbers of fish taken.

Other disturbances in the Gulf of Saint Lawrence fisheries occurred at the time of the fungus disease outbreak in herring. Landings from the long-line fishery for cod on the Gaspe coast decreased drastically coincident with the onset of mass herring mortalities, while the trawled catches remained unchanged. The lobster fishery along the northern New Brunswick coast also suffered an almost immediate decline when herring mortalities began, probably because of the abundance of food outside the traps. Recovery of both the cod and lobster fisheries was rapid, however, in late summer and autumn, after the mass mortalities of herring had ceased (Sindermann, 1956).

Viewed in this way, disease outbreaks may be catastrophic to the host population, but temporarily quite beneficial to predator or scavenger species, some of which may have a higher unit value to man than the affected species.

OTHER DISEASE PROBLEMS

Disease may be an important environmental factor at any stage in the life history of marine animals. Evidence from herring studies suggests this (Fig. 7), but evidence is particularly weak for the earliest life history stages where effects are apt to be most pronounced. Sizes of year classes are often determined very early in life—by relative survival of eggs, larvae, postlarvae, and juveniles. Eggs of marine fish are often coated with microorganisms, and Oppenheimer (1955) found that hatching percentages of sardine, flounder and cod eggs were increased in a bacteria-free medium. Fungi have been reported as parasites of crab and gastropod eggs (Atkins, 1929; Couch, 1942; Sandoz, *et al.*, 1944; Ganaros, 1957). Abnormalities, some of which may have been due to disease, were noted by Ahlstrom (1948) in up to 45 per cent of Pacific sardine eggs. Juvenile herring schools in their natural environment have been observed to contain individuals with bacterial tail rot (Sindermann and Rosenfield, 1954a) and in laboratory studies such infections have been found to be fatal within five days. These few examples suggest that disease effects on early life history stages of marine species can constitute a challenging area for future research, particularly that oriented toward understanding factors that determine abundance. While the success or failure of year classes may be influenced by many other environmental conditions, disease could play a major role in survival of early life history stages.

Another critical area of research concerns the effects of marine epizootics on the subsequent relationship of pathogen and host species. Varying degrees of selection pressure are exerted by epizootics, depending on their severity and duration. We have little

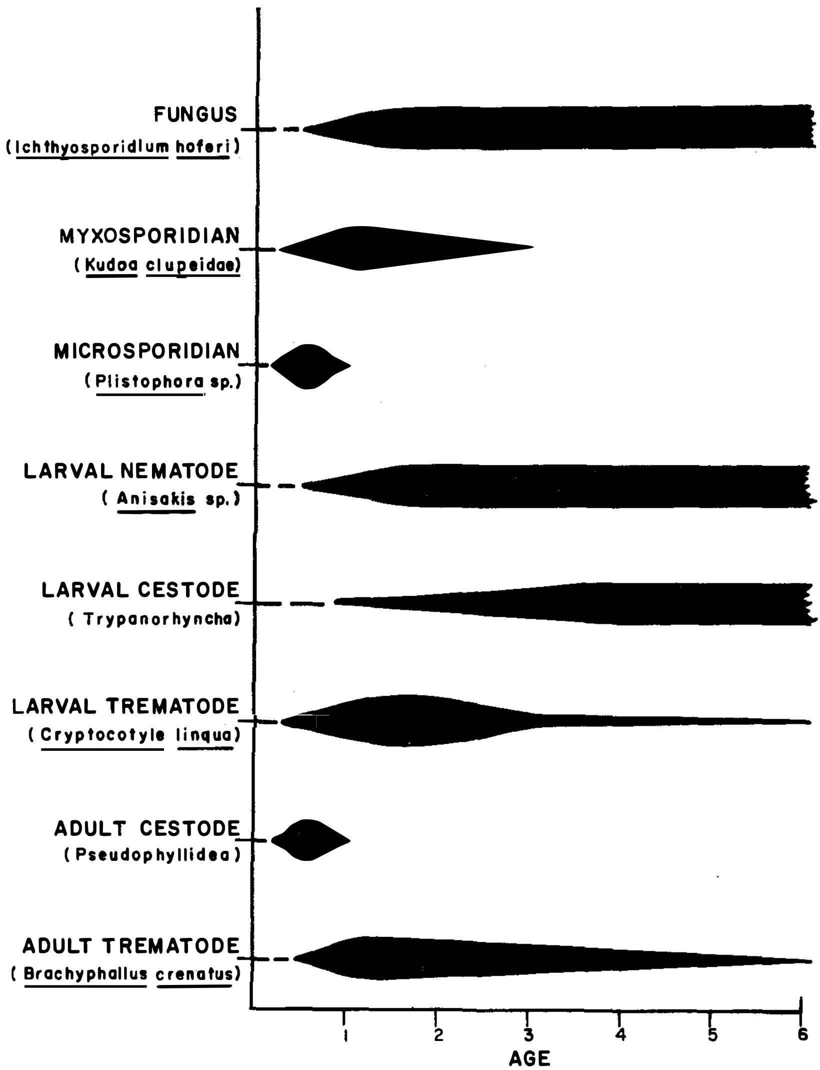

Figure 7. Relative abundance of diseases and parasites in herring of various ages. Dashes indicate lack of information.

information about the nature of resistance of marine organisms to disease—whether it be innate ("natural"), or acquired by previous exposure to a pathogen. Herring were found to vary individually in responses to massive experimental exposures to spores of the fungus *Ichthyosporidium* (Sindermann, 1958). With identical spore dosages, some fish acquired acute infections and died within one month, some acquired subacute or chronic infections that persisted for as long as one and one-half years without killing the host, while some appeared uninfected, even after careful histological examination. Decreased incidences of acute infections were demonstrated in experimental groups of fish challenged by re-exposure to massive spore dosages, but attempts to demonstrate circulating antibodies by precipitin tests as well as hemolytic tests using tannic acid-treated antigen-coated erythrocytes were not successful. Four known epizootics have occurred in Gulf of Saint Lawrence herring, with no observable decrease in severity. On the other hand, information from study of Gulf of Saint Lawrence oyster mortalities which began in 1915 suggests that selection pressure was severe enough to cause a change in population susceptibility to an unknown pathogen. Oyster transplants from other areas were killed even many years after mortalities of native oysters had ceased. This indicated that the causative agent was still present, and that the surviving native stock was resistant, even though the nature of the resistance or, for that matter, of the pathogen, has not been demonstrated.

A final problem, especially acute in pelagic and other offshore fishery research, is that of observation of disease and the proper evaluation of its role. Diseased individuals may be consumed rapidly by predators, and fish dead from disease may be quickly disposed of by scavengers. Epizootics may come and go with no or almost no observations. Extensive mortalities may receive only sporadic examination, so that causative factors are usually not discovered, and the dimensions of disease impact on population size remain obscure. As an example, it is quite possible that the same fungus disease epizootics characteristic of Atlantic herring also occur in Pacific herring. Foerster (1941) and Tester (1942) reported herring and pilchard mortalities off Vancouver Island, British Columbia, with features remarkably like those observed during fungus outbreaks in Atlantic herring populations.

AN APPROACH TO DISEASE CONTROL IN THE SEA

The original and persistent attitude toward disease in marine species has been that the environment imposes overwhelming obstacles to control or prevention of losses due to epizootics. There are, however, several things that can be done:

1. We can *understand* the ecological role and consequence of disease, in terms of abundance of commercial fish and shellfish species particularly, through continuous research.

2. Based on such understanding, we can hope to *predict* when outbreaks will occur. This would require continuous monitoring for changes in abundance of known pathogens, and for the appearance of new or previously unrecognized pathogens.

3. Finally, we can hope to *control* disease, particularly in inshore populations. With shellfish, control might take the form of development of disease-resistant strains. The natural environment seems to have successfully carried out the first phases of such an experiment in Prince Edward Island oysters. With inshore fish species such as herring, fungus disease control might take the form of actual addition of cultured spores to the sea, to artificially maintain the disease level at a point at which population resistance is continuously just high enough to prevent epizootics. Another approach might be deliberate overfishing of a population as soon as evidence of an incipient epizootic is discovered.

The fact remains that disease wastes protein that could be utilized by man. While natural checks on population growth and size are important for all species, the substitution of increased fishing mortality for decreases in certain parts of natural mortality of commercial species—such as that part caused by disease—could be important in the future.

SUMMARY AND CONCLUSIONS

Of the natural factors that influence abundance of marine organisms, few are more spectacular or less understood than disease. Studies of diseases of marine animals have been carried on sporadically in recent decades, usually during times of epizootics in economically important species. Our information about the total role of disease in the sea is still incomplete, but evidence supporting certain generalizations has accumulated. In several studies, particularly those of Atlantic herring and oysters, epizootic disease has been related to changes in abundance of marine species. Disease outbreaks in one species have had pronounced positive or negative effects on other ecologically related species. Individual variations in susceptibility of marine organisms to particular pathogens have been demonstrated, and in at least one case a change in susceptibility of a population was indicated. Recent demonstration of specific immunological competence in fishes suggests that antibody response may be an important mechanism of resistance. Such findings indicate that the controlling factors involved in marine disease outbreaks are not fundamentally different from those underlying epizootics in terrestrial animals, and certain major fluctuations in abundance of commercial marine species may well have been related to disease.

Increased awareness of the role of disease in marine populations has come from study of epizootics and mortalities in a few species of commercial importance. Pronounced effects on population size have been demonstrated, and it seems plausible that continued and expanded research will establish the importance of disease in the ecology of the sea. Disease has often and unrealistically been considered as a "constant" factor in determination of theoretical mortality rates for commercial species. Greater research commitment should provide a more factual basis for such analyses.

Research commitment and interest often expand and contract with disease incidence. We need stable long-term studies of causes and effects of epizootics. Epizootics and mortalities of oysters on the North American East Coast have probably received the greatest research effort, past and present, and serve as examples of the complexity of disease problems, even with sedentary inshore marine organisms. At least three pathogens have been implicated: *Dermocystidium marinum,* especially common in more southern areas; *Haplosporidium costale* recently described from Virginia (Wood and Andrews, 1962; Andrews, Wood and Hoese, 1962); and an undescribed haplosporidian (MSX), thought to play a role in recent extensive mortalities in Delaware and Chesapeake Bays (Andrews *et al., op. cit.*). Although advances have been made with descriptive and life-cycle studies, many gaps still exist in understanding of epizootics, transmission of pathogens, and susceptibility of hosts.

Those pathogens that have received most attention belong to an amorphous group variously assigned to the lower fungi or the poorly defined protozoan order Haplosporidia, (*Labrinthula* from eelgrass, *Dermocystidium marinum* from oysters, *Ichthyosoridium hoferi* from herring, *Haplosporidium costale* from oysters, an undescribed fungus from sponges, an undescribed haplosporidian (MSX) from oysters, to mention only a few). A few bacteria, such as *Gaffkya* of lobsters, have been identified as pathogens (Snieszko and Taylor, 1947), but to a large extent the role of bacteria and viruses as marine pathogens is incompletely understood. Facilities for recognition of viruses in marine organisms have usually not been available when mortalities have occurred. Some examinations for bacterial pathogens have been made during or after periods of mass mortalities, but reinfections from cultures have often failed or have not been attempted.

Here, then, is an area of marine research deserving of further exploration. Disease can be an important determinant of population size, whether the population be fish, oyster or sponge. If we are ever to understand the ecological systems that govern the yield of fishery products, we must scrutinize the maladies—epizootic and otherwise—to which marine populations are subject.

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DISCUSSION

MR. FISHER: Not many years ago, one of the many Russian world-roving research vessels cruising in the Indian Ocean ran across an immense number of floating dead fishes and a primary calculation by them was that that kill was equivalent to the total annual production of the world catch of fish. This is an area that is completely unexploited today in fishing. Whether or not the reason for the immense fish kill was determined—apparently it was a disease—the possibility of such phenomena on a similar scale in our own coastal waters points out the great need for study of diseases in fishes and other marine populations.

Thank you, very much, Dr. Sindermann, for this excellent and beautifully illustrated paper describing tremendous progress made in the very complex field of diseases.

One thing I would like to know is what tests are made in this kind of an infection, so that infected fish are not getting onto the market. I take it there is no particular toxic effect from these infected fish.

DR. SINDERMANN: Fish infected with the fungus organism definitely do get on the market. In fact, I was served infected fish on several occasions on the Gaspe Coast while we were studying the disease. Apparently, though, this is a disease confined to lower vertebrates and to invertebrates. We have done some experimental work with laboratory mammals, and have never been able to achieve infection by any possible route. It is found in a number of other fish species, and there are many interesting ecological aspects, but there seems to be no danger to humans from ingesting this material as far as our work with other experimental mammals is concerned. However, the Pure Food and Drugs people take a rather dim view of this organism, and this is one of the reasons why we have continued to study it, even though it is rendered, of course, incapable of any kind of infection by cooking. During the last outbreak in 1947, in the Gulf of Maine, some packs of sardines were seized because of the presence of fungus spores. This is a habit, I guess of the Pure Food and Drugs people, regardless of the nature of the fungus spore, that if the count exceeds a certain proportion, the particular lot is condemned. This occurred during that one year, and culling methods were immediately set up, but the disease declined into the post-epizootic phase in the following year. No further trouble resulted, but to the best of our knowledge, there is no danger to humans.

MR. MORTENOW [University of Michigan]: I think this is a very fine paper of wide adaptation for use in the study of bird populations. In birds, we frequently have epizootics and the numbers seldom exceed 10 per cent, and very rarely 20 per cent of the total population, and as a matter of an individual variation it renders the birds susceptible to death under these conditions, and it is of major interest to me. Can you give us any more information on the nature of the variations you have found and particularly their relation to birds?

DR. SINDERMANN: We have worked in the Gulf of Maine only with immature fish principally because this is about the only kind of fish that we get. Adults are further off shore, as a rule, and are not taken by the commercial fisheries, so our experimental epizootics were with immature fish, usually, too, with fish in their second or third year of life. We did find that below a certain level of spore dosage, all infections were sub-acute, and then beyond this point, we began getting increasing frequency of acute infections. These are rather sharply limited, although I expect there is a transition here, too. The acute infections are characterized by extensive necrosis without any great tissue response on the part of the individual fish, whereas the sub-acute or chronic infections which may persist in our tanks for up to 18 months are characterized by round cell infiltration, connective tissue incapsulation, pigment response immediately surrounding the spores, and so on, so that the two categories are reasonably distinct. These two persist at about one part of acute infection to two of chronic or sub-acute, and it is interesting to us that this is about what we found in populations of herring in nature taken in the Gulf of Saint Lawrence. The fishery up there is by gill net and tends to be non-selective, except that it does take adult fish. The timing of the epizootics is rather interesting, too, in that the fish come inshore about a month before they spawn, and apparently they acquire the infection as soon as they move in, from spores that we have been able to isolate from inshore bottom sediments. They then begin dying at about one month, following the inshore movement, so that some of them, in fact many of them, probably have spawned before they are killed, at least in the first year, as we have a two-year epizootic period.

MRS. GRACE MURPHY: I am desperately interested in the effect of dredging on fish, and I cannot get as much data as I want. I am wondering if there are any permanent effects in both the offshore values and the harbors as well. Can you give me something on that subject?

DR. SINDERMANN: I am not sure that I can satisfy you very much. I have tried in my work with marine populations to take a fairly broad view, and about the only statement that I would care to make is that with most marine species, except for those that are strictly intertidal, man's effects are probably less important than natural phenomena. To me, predation and disease constitute the overwhelming environmental variables, and other factors are less important. Now, it can't be denied that in strictly inshore waters many of man's efforts have been deleterious to fish populations. As far as the offshore banks are concerned, I don't see how trawling—and I think you are referring to trawling—would have a serious total effect on the species except for those very limited banks that are gone over time and time again during the spawning season, and here, I am sure that some effect would be produced on the eggs, primarily those fish that have eggs that attach to the bottom.

DR. LONGHURST: I was wondering if you have any evidence that these diseases are in any way density connected?

DR. SINDERMANN: Insofar as the fishery is any indication of abundance of a marine species, and often it is a very poor indicator, there is some evidence that the past two epizootics, which were the two studied most intensively in '47 and '55, occurred in times of relative abundance of herring. This is probably the only detailed information we have, and this is not too detailed. We did notice, for example, that in the early 1950's, before this outbreak, herring were numerous enough in the Gulf of St. Lawrence that they were spread on fields as fertilizer, and in the post World War II years just preceding the 1947 outbreak in the Gulf of Maine, again herring were abundant enough so that catches in some cases could not be accepted by the processors. This might, of course, have been related to economic conditions, as well. So again, as far as data from the fishery gives us a clue about abundance, there does seem to be association of outbreaks with high density of population.

Dr. GUSTAF SWANSON [Cornell University]: In this very fine paper, in referring to the epizootic and showing us the slides indicating incidence, I believe you used the term "periodicity." I would just like to comment on that because as I read those charts, I would use the term "neat irregularity" instead. Periodicity means recurring at regular intervals. It means being predictable, and I think we have been so oversold on the idea of cycles and periodicity that we conclude there is periodicity where it does not actually occur. We feel that these epizootics actually do periodically appear and almost can be predicted.

DR. SINDERMANN: We started out with our work on this disease with the idea that this was not a periodic thing, but evidence has accumulated to the point where if you don't like the word "period," some other, and possibly, "cyclic phenomena" would be in order. It's not perfectly regular, but when you look at the number of possible environmental variables that could influence this, I think it is not outside the realm of periodicity to have a range of maybe 10 years between epizootic peaks. Now, our earlier work in the Gulf of Maine showed two definite outbreaks. We had three in the Gulf of Saint Lawrence, and have recently come up with a fourth one there from rather obscure reports. If four outbreaks spaced roughly 15 to 25 years apart is not some evidence of a cyclic or roughly periodic phenomenon, then I think we will have to wait for one more. In fact, we are waiting for such an outbreak now in the Gulf of Maine. We are following both these gulfs every year in terms of incidence, and our picture, of course, won't be complete until we can carry these observations through an entire outbreak period. Our practical reasons, of course, are obvious. We need, first of all, a prediction of when the next outbreak will occur, and I think we can get this. The last two outbreaks have been characterized by several years of increasing the incidence. We need also to think about controlling this thing, and I don't think this is outside the realm of possibility, either, but I won't argue with you about the disease periodicity, except to say that four outbreaks constitute, to me, evidence that something rather regular is going on.

FISH-PASSAGE RESEARCH IN THE COLUMBIA RIVER BASIN

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For thousands of years, migrating salmon and steelhead of the Columbia River system have adapted to the conditions prevailing in different parts of the Columbia River Basin. They enter the river, from the sea, at various seasons of the year: in the spring, in the summer, and in the fall. Some migrate only a few miles to spawn, while others swim upstream for more than a thousand miles. Some spawn in large rivers, some in lakes, some in cold mountain streams. Each group in its way has adapted so as to live in harmony with a specific environmental pattern—with a particular sequence of events, all of which have meaning to its existence.

Now, in a few short years, the development of the entire river system for power, irrigation, navigation, and flood control is making sudden, enormous changes in the environments to which the fish have long been adapted. Where swiftly flowing rivers were, a chain of lakes is being created. Freshets and floods that may have played a major role in the transport of fingerlings to the sea are being controlled. Temperature regimes that govern rates of growth and maturation are being modified. In the changed environments, new predator, competitor, and disease relationships are being established that may greatly affect the survival of the migrant fish. Add to these changes the physical barriers to migration created by many dams and the complex nature of fish-passage problems in the Columbia River system is made clear.

The necessity for providing methods for the safe and economical passage of migrating fish over the physical obstructions of dams is an obvious one, and a reality that must be faced. An even greater challenge, however, is the task of anticipating the adaptability of the stocks of fish to migration in the new environments that will be created by dams and developing methods to protect the fish where environmental changes may be too severe. All of the factors that affect the behavior and survival of anadromous fish on their migrations from the gravel to the sea and from the sea to the spawning nest must be considered if we are to provide safe passage for salmon. The need for information is particularly critical in five major areas:

1. *Effect of Impoundments on Fish Migration.*

A large part of present research effort is directed toward measuring the effect of impoundments upon the migration of salmon. The basic question to be answered is whether the large impoundments that would be created by high dams would be impassable barriers to migratory anadromous fish. The problem is being studied in large and small impoundments in Idaho, Washington, and Oregon with chinook, silver, and sockeye salmon and steelhead trout. The research on downstream migrants includes estimation of recruitment to the impoundment, noting timing, size, and condition of the migrants; distribution and behavior patterns in the impoundment in relation to limnological conditions; estimation of survival and escapement from the impoundment and relation to size, condition, and age of the fish. Orientative behavior of adult salmon released in the reservoir and the ability of adults to pass through the impoundment and successfully reach spawning areas are being measured.

2. *Collection and Transportation of Downstream Migrants.*

In anticipation that certain types of impoundments may be impassable to some species (or races) of migrant fish, an important part of present research is on the development of practical and economical methods of collecting young fish from streams and from the entrance to impoundments. Methods of fish guidance and collection presently in use are only partly successful, or not applicable to large projects, or overly expensive. Research is now exploring the possibilities of more effective combinations of techniques that have shown promise in the past and developing new concepts of fish guidance and collection.

The use of louvers to collect downstream migrants from flowing water is being tested on a large scale at both fixed and floating installations. Further experiments with electrical guiding have been postponed, however, after data from tests indicated that its effectiveness is limited to velocities of less than 0.5 foot per second. New guiding concepts involving the response of fish to changes in water velocity are being developed and will be tested on a prototype scale at special test facilities now under construction on the Grande Ronde River in Oregon. The possibility of collecting downstream migrants as they first enter an impoundment is being explored at the Brownlee Reservoir in Idaho, attempting to take advantage of the tendency of the young migrants to stay near the surface. Facilities and methods for holding, handling, and transporting the collected fingerlings are to be studied and tested. An investigation of means of controlling the spread of disease in fish concentrated for transportation purposes is in progress.

3. *Passages at Dams.*

The long sequence of river-run dams that fish must pass through in the Columbia River Basin makes protection at river-run dams an important factor in the survival of upper river stocks of salmon. Research is in progress on means of protecting downstream migrants in turbines, attempting to take advantage of the special distribution of fingerlings in turbine intakes and its relation to the cavitation producing areas that are believed to be the major source of injury to fish. Adult studies are planned to determine the effect of spillway operation on the effectiveness of entrance conditions and on fallback of salmon that have already ascended fish ladders. The relation of fishway-exit location to fallback activity will also be studied. Studies at the Fisheries-Engineering Research Laboratory at Bonneville Dam are directed toward the development of design criteria for effective and economical fishways.

High dams, particularly storage dams with fluctuating forebays and intermittent peaking operations, may not have any satisfactory means of exit from the reservoir available to young fish during the time of migration. Information is being sought on effective methods of providing egress for migrants where no spill is available. Facilities proposed for passage of adults at high dams would in some cases subject the fish to unusual stresses. Studies are in progress to measure the ability of salmon to withstand the conditions that would be imposed.

4. *Racial Physiology and Behavior.*

An important phase of fish-passage research is concerned with the adaptability of racial stocks of salmon to environmental changes anticipated with the construction of dams. Increased effort is being put in the prediction of the effects of proposed new dams on water temperature, oxygen, and flow conditions for analysis in terms of salmon passage and production. In order that the ability of anadromous fish to adapt to such changes in environmental patterns can be predicted, information is being sought on the limits of the inherent capacities of the fish and how these relate to existing and predicted environmental patterns. A study is being made of racial migration rates and timing, and the nature of the homing mechanism of salmon is being investigated for relation to predicted future conditions.

5. *Effect of Temperature Level on Survival and Migration.*

The new fresh-water environment being created will determine the potential for success or failure of the upper river stocks of anadromous fish in the Columbia River Basin. In our frantic attempts to solve each set of problems created by each new dam, we are in danger of neglecting more important opportunities to develop some measure of large-scale environmental control that could be of immense benefit to anadromous fish. It is paradoxical that high storage dams that threaten disaster to anadromous fish runs that they intercept also have the potential capacity to control river temperatures within ranges of extreme importance to fish. Maximum water temperatures now reach into the seventies on the Columbia River and into the eighties on the Snake River. Unfortunately, the planning of the great storage reservoirs on the upper Columbia River includes no attempt to provide downstream temperature control. It would be extremely shortsighted if a similar situation were permitted to develop on the Snake River. Research is needed on the direct effect of water temperature on the migratory behavior and survival of anadromous fish. To fully appraise the benefits to be gained by control of water temperature, however, information is also needed on the effects of water temperature level upon disease and upon warm-water species of fish that compete with and prey upon anadromous fish as they pass through the long sequence of impoundments during their migration.

DISCUSSION

MR. A. T. PRITCHARD [Washington State Game Commission]: My remark is not directed as a question but the matter of a statement which was in the paper. I think particularly our people in the central part of the United States and eastern part of the United States are not aware of some conditions of the high dams which haven't been covered in this paper. On normal dam structures fish migrating upstream seem to get through quite well on the basis of not being handled, but we get into the problem of our higher dams, like the Lewis River and Callas River Dams in Washington where they are using a British-type operation. I think this is something we should be a little more cognizant of in your unprotected stock. At the Lewis River, it took 10 years to kill off a spring run salmon population. This was done again through an elevator-type and a handling operation. We have gone into a similar type of operation in the south again with the Braille, and to cite an example, the Game Department of the State of Washington trailed as carefully as we could some stocked steelhead, which is a very important fish in these streams, and we moved them no greater distance then than they are moving the fish in California today. We took 60 fish, handling them very very carefully, and in a period of two months, we lost every single fish. This was with extreme care, not in the manner they are doing at the present time on the Callas River, where with the brailling they have a short ladder system. They go into a traveling braille operation, are dumped into a truck and hauled several miles and dumped back in behind the dam. I am afraid that our people are not making progress. It is a point I want to bring out. We should look a little harder at this point.

MR. FISHER: Thank you very much. Mr. Collins mentioned here studies on orientative behavior of adult salmon. I might mention briefly in passing the studies on orientation and celestial navigation of downstream migrants, and I think some downstream migrants, too, being carried out by British Columbia, and I am on the research board. One factor, as I remember, from a summer ago up there is in any positioning of the behavior that they have discovered from their studies on celestial star and sun navigation, and positioned behavior in downstream migrants, that they take up even when experimental leads indicate that it is in total darkness, the point being that here, possibly, is another complex factor in the design of fish passages. It may be of great advantage to design in such a way as to interfere as little as possible with the steelhead in a group orientation behavior.

A VOICE: I'm from Oregon. I would just like to make a little amplification of Dr. Collins' paper. Dr. Collins is aware, as we have discussed it and that is the matter of water quality that we get into on a number of projects. We used to think we could put the fish over any dam merely by building a ladder and the fish would go up. This proved true on our main attempts on Columbia River dams and a lot of other western dams. However, some of the smaller areas where we first started looking matters over, in dams that created stratified reservoirs, we found that in the summer areas, these conditions developed a different type of waterfall in coming down a fish ladder than was issuing from the turbines, with the result that the fish refused to enter fish ladders because the flow was different than that in which they approached the obstruction. This is a factor we are recognizing now on the West Coast and there are ways of getting around it. However, I was a little bit concerned about some of this work being done and proposed for the Susquehanna and some streams on the East Coast because there is every chance that the same thing will happen there, and I see no visions for adding discussions that don't add anything, and I think it is something that could well be taken advantage of and studied in advance before several million dollars are spent for fish ladders that prove utterly unacceptable to fish.

MR. ARNOLD GOLD [Oregon State Game Commission]: I would like to elaborate on one facet here of Dr. Collins' paper. When he speaks of racial stocks, let me point out that in my opinion what he is talking about is the various races of a single species. The spring run of fish, for example, in the Columbia has a great number of racial stocks. In other words, there are those that are going up the Collins about which the gentleman just spoke. There are those who go up the Helena, up the Fuse, and a variety of other streams that connect to the Salmon River in Idaho. You will find those fish are entering the main stem of the Columbia at different times. They have different spawning times. For instance, the Imneha River in Oregon which empties into the Snake River, slightly upstream and across from the Salmon, the fish, the spring chinook—the species is the same —are spawned out a substantial length of time before those in the Salmon River, while the spring chinook that are inhabiting the McKenzie River, a tributary to the Linan, won't be spawned out until summer and mid-September. Those of the Imneha will have spawned and died by the middle of August. The same situation applies to practically every species of salmon using that river. I might point out in the Rogue River, which is completely separate from this, we can at the present time identify seven different races of steelhead alone. There may be more.

MR. FISHER: Thank you very much for finding out your problems. I think perhaps we should move on.

A SUGGESTED PROGRAM FOR SAFEGUARDING THE "HIGH YIELD" AREAS OF OUR COASTS

RICHARD H. POUGH
Chairman, Coastal Wetlands Council, New York City

Coastal habitats for both aquatic and terrestrial wildlife are the end product of the interaction of a most complex and variable set of factors. As a result there is a variation in the quality of the environment that various coastal areas provide for waterfowl and aquatic wildlife.

Because of the mobility of many of these forms of wildlife and the critical nature of their habitat requirements during certain stages of their life history, the key to their continued abundance over extensive sections of the coast and the adjacent marine environment lies in the preservation of areas of critically important habitat.

Some areas that were once important have been destroyed by urbanization and industrial development over the past century, with the result that many species are increasingly dependent on a few remaining unspoiled areas.

Now that research studies are clearly "pin-pointing" some of the more productive of the remaining coastal areas, steps must be taken promptly to insure their permanent preservation.

Unfortunately, to date, the attempts of conservationists to cope with the problem have been rather "hit and miss." Certain tracts of marshland have been placed in public ownership, fights have been waged from time to time against specific proposals for industrial development, but little over-all protection has been placed over any sections of the coast.

Large corporations run by laymen with no knowledge of biology have had the disconcerting experience of retaining engineering firms to select sites for new plants only to find when they started to buy the land that a militant group of local conservationists were ready to fight to the death to prevent the destruction of resource and recreation values that the corporation executives involved never knew existed.

It might be well to explain at this point that my professional training was in engineering at the Massachusetts Institute of Technology. As a result, I know how little biology the average engineer gets in the course of his professional training and how unreasonable it is to expect him to know all about coastal and estuarine ecology.

Every engineer knows what attributes a site must possess, such as the availability of various types of transportation, supplies of water, etc. However, he seldom knows anything about oyster beds, shrimp nursery grounds, waterfowl concentrations, and probably has no realization of how offensive the smells and structures of industry are to many people.

Doesn't such a situation impose an obligation on the country's biologists and the agencies of government charged by law with the safe-guarding of the natural resources of the coastal region to clearly identify the crucially important "high yield" areas that must not be disturbed, to publicize their location and ask for the cooperation of industry in avoiding them?

I am sure no corporation wants to deliberately destroy an area that is the key to the annual production of millions of dollars worth of seafood or spoil healthful recreation for thousands who enjoy sport fishing and hunting. As our population mounts toward two hundred million, we are all becoming acutely conscious of the increasing necessity to approach all changes in land use cautiously and evaluate all proposals in terms of their impact on natural resources and the welfare of every citizen.

I feel this is especially true of engineers. During my training it was stressed that as professional men we were under just as great an obligation to protect the public from harm as we were to help our employers make money.

I would like to suggest that state and federal agencies publicize at once by every means at their disposal those coastal areas they now know to be of critical importance to wildlife. I feel sure that it this is done, our industrialists can be counted on as good citizens to avoid them.

Should any be attempted to try to put installations in them in the face of such warnings, I believe the national conservation organizations are strong enough today to make them regret their folly and change their mind. After a few corporations have had such experiences I am sure the temptation to invade these clearly defined "high yield" coastal areas will be very slight.

We have already witnessed in recent years a number of most unfortunate and costly controversies over the location of new oil refineries and the petro-chemical plants that seem to spring up next to them.

The attempt of the Universal Oil Products Company to locate a refinery on Jamestown Island in Rhode Island's Narragansett Bay is reputed to have cost the company several hundred thousand dollars to date, and their bankers, New York City's Lehman Brothers, something like a million dollars. What it has cost the Narragansett Bay Home Owners Association I can only guess. The tragedy of it is that what went into this essentially sterile fight was on the public side undoubtedly diverted from badly needed, constructive local civic enterprises.

An attempt by the Frontier Oil Company to locate a refinery on the Banana River near Coca, Florida, raised a similar controversy, and before it was defeated a lot of money, time and energy that might have gone into constructive activity were expended both by industry and the local conservation interests.

More recently the Shell Oil Company decided they liked the looks of a site on Delaware Bay just north of the Bombay Hook National Wildlife Refuge. If they had tried, they could not have found a more inappropriate place. Their plans call for the construction of a pier running over a mile into the bay. A location that would place it close to the Bay's precious oyster seed beds—one of the only two that remain on the Atlantic Coast. Such a location for the hazardous loading and unloading of oil tankers would practically insure that oil from the "accidental" spills that every refinery has would be carried by winds and tides into the most remote corners of the vast complex of salt marshes that border both sides of the Bay. Marshes that support great flocks of waterfowl in the fall, winter and spring and provide the nutrients that support the most valuable fishery unit of the Atlantic Coast.

The fight, which is still going on, is reputed to have cost the oil company several times as much as the land they have purchased, and badly needed conservation programs are at a standstill in the area until the matter can be resolved.

Now a similar situation has flared up south of Miami. The Seadade Realty Company are seeking to pave the way for the construction of an oil refinery on Biscayne Bay that would apparently be tied in to an offshore bunkering arrangement which has a high potential for "accidental" spills. At least half of greater Miami—a city that many people live in for pleasure rather than necessity—would be in the "fume shadow" of such a refinery. Competent biologists are alarmed at what such a refinery might do to the rich sports fishery of the Upper Keys, the new undersea National Park and the varied bird life that does so much to make the region interesting and an attractive place in which to live.

It would appear that these cases—and I could cite many others such as Bethlehem Steel's attempt to take over a most scenic and unspoiled potential recreation area near Chicago—are only a mild foretaste of what is likely to come if we don't act a bit more mature and civilized. It seems to me that those responsible for developing increased industrial capacity for the country and those concerned with safeguarding its beauty and natural resources have got to sit down with full respect for each other's interests and points of view and work out sensible solutions to the problem of finding appropriate locations for additional refinery capacity. There has been nothing constructive about the controversies I have described, and the problem remains unsolved.

It would appear that the key to the success of such a program lies in the prompt identification of the truly "high-yield" areas of the coast and a clear delimitation of their boundaries. If more research is needed to define their exact limits, it should be given a high priority in the programs of the agencies involved.

Maybe it's the engineer in me coming out, but I feel that the engineering firms that industry retains to select sites for new plants are entitled to know where they can look for sites for oil refineries, chemical plants, steel mills, smelters and other industries that create an actual or potential air and water pollution threat without running the risk of stirring up a hornet's nest of protests from conservationists to embarass their client.

Should industry not be willing to cooperate in a program along the above lines, legal zoning of the coast may well become necessary. Failure to protect either voluntarily or legally such areas as the oyster seed beds of the Delaware and James Rivers, or the coastal bays of the Gulf that serve as nursery grounds for shrimp during their juvenile stages could destroy fishery resources just as valuable as the salmon runs of the West Coast to preserve which millions have been and are being spent on fish ladders.

My purpose in presenting a paper at this Conference is to take advantage of the presence here in Detroit of the country's leading biologists and conservationists. Instead of considering you a captive audience, I would like to tap your collective experience and knowledge for specific examples of industries that have located or tried to locate in inappropriate places. By what means and on what grounds were they blocked? Were those involved on industry's side quite ignorant at the start of the natural resource aspects of the matter? What was their attitude once they understood the situation? If the plant was built despite protests, what has been the impact to date on the wildlife resources of the area?

Even more important, I would like to ask you to let me know either now or later by mail what areas you think should at once be protected with the kind of voluntary zoning I suggested as the first step toward coping with this problem.

The fate of our coastal fishery resource and the salt water frequenting waterfowl of the Atlantic Flyway hang in the balance but I believe a sensible solution can be found that will be in keeping with our American tradition of voluntary rather than government action and respect for the basic rights of one's neighbors.

It is certainly a solution that the Coastal Wetlands Council, of which I am chairman, would like to see given a trial.

DISCUSSION

MR. HERB ALLEN [Upper Keys, Florida]: This question of the oil refinery has been uppermost in my mind now for about a year. We would be very happy if Mr. Pough's group would suggest some other site, preferably at least a thousand miles away from Miami, for the installation of this oil refinery. Anything that could be done along that line of construction, we would appreciate. Thank you.

MR. FISHER: On the map of the areas, I am sure Mr. Pough has this in mind. There are areas that are available and suitable for industrial development, and it is equally important that the high yield areas are points to avoid.

MR. DAVID POWER [San Francisco]: I would like Mr. Pough to comment on, perhaps, an alternative to industrialization of these areas which are important for their scenic or recreational values. Just slightly north of San Francisco we have an area you may have heard of, Bodega Head, which had been on the State Park master plan in California. Money had been appropriated for that purpose. It was also considered available for a site for a marine laboratory for the University of California for marine and mammal serearch, but a major utility also picked that site after these things were known and moved in there and is preparing to build an atomic reactor, one of four which is on their boards, so possibly, Mr. Pough, we need to find some way to do more than that. We need help not only on the land, but to impress the importance of the area map onto engineering lines, should we say? Would you comment on that?

MR POUGH: Well, the reason I included in my paper a little summary of some of the recent fights in which industry has not come off too well is to indicate that we do have a club, if they don't cooperate. I think that club is growing stronger all the time as our conservation groups grow stronger. I think if industry will look at the picture rather carefully, they will see that there is a lot to be gained on their side. In fact, if they are smart, they will put us on the spot as I suggested, and say, "All right, where shall we put it?" and that's the reason that I think we need the help of biologists in knowing exactly what areas are priceless and to see what the gaps are and look into those areas, we can direct the industry too. Now, this may be only a first step. I spent a month in Britain last year, and there the Nature Conservancy has the legal right to draw a circle around any area on the map of Great Britain, and they have drawn a great many. They are known as sites of special scientific interest, and once the Nature Conservancy has drawn such a circle on the map, no change in the basic use of the land may be permitted by the planning board that has jurisdiction—and every county in Britain has a planning board—without a full-dress hearing at which the Nature Conservancy, drawing on the knowledge of the scientists of Britain, present the reasons why it is inadvisable to permit this change in use. In the overwhelming majority of cases, the industry, or whatever it happens to be, has been told, "Too bad, boys, you will have to go somewhere else." It works extremely well, but there they are using a government club. Industry has no alternative. They are told they cannot do it.

Now, we are a long way from that sort of thing in this country. I hope we won't have to come to it because we have a lot more room. These things aren't nearly as much at the crisis stage—a critical running out of space—and it seems we have ample opportunities to direct for a good many years to come the installation of new refineries or new capacities to areas already blighted. Twenty refineries aren't going to do much more harm to an area than one. What with one doing damage to shellfish, fish tainted and killed out in an area, adding a little more will not make a lot of difference. We can direct them to a place like Raritan Bay which was once a fine oyster fishery that is now completely gone, and which I suspect is a place for a lot more oil refineries. We are just beginning this thing, and I haven't all the answers, but I would like your help.

MR. E. A. SEAMAN [Virginia]: Some of the federal people in the audience may know the answer to this. I wish I had more information on it myself, but a number of years ago there was a recreational map put out by the Federal Government, I guess U. S. G. S. I have a copy of a federal warrant showing all the national forests, all the national parks, wildlife refuges, state parks and forests and everything across the nation. Not long ago, I heard this map was up for revision, a monumental job. I wonder if any federal person in the audience knows whether or not a decision has been made to revise this map? The reason I bring it up, Mr. Pough, is that in my experience as an advisor to the Air Force on natural resources, our military people are alarmed when I lay this map down in front of them when they are thinking in terms of additional bombing and gunnery ranges, and other areas for defense purposes, particularly the Air Force. They are utterly frustrated and astounded to realize how many recreation areas there are in the United States, and in how many places and how intensively located they are. This is a good kind of frustration, but I would like to have a new map which is up to date and shows all these areas throughout the country, and I am sure such a map put in the hands of industry and engineers might have a nice frustrating effect on them, especially as regards our coastal areas. I notice in the military, as an example, as they see this tremendous location of recreational facilities throughout the country they think, "Well, now, maybe we'd better sit down and think this over." Strange as it may seem, as a biologist myself, I have a unique position of being on the Air Force Bombing and Gunnery Range Board. I think this is probably an unusual place for a biologist to be. I doubt if in the history of any country a biologist has ever gotten placed on a board that would be concerned with military matters of bombing and gunnery ranges, but the significant reason for placing me on that board is that you can't fly an airplane and you can't do much in the defense business where you are involving air, water, or land without being somehow dependent on the natural resources people, recreation people, and so forth. I feel if there is a problem of getting this map reprinted and brought up to date, I suspect that the Bureau of Outdoor Recreation is working on this. I say just in passing comment that the map should be revised, but it is going to cost a lot of money, and Congress would probably have to have a special appropriation to do it. I will recommend, though, that you and others here support the revision of that map and use it when you can.

MR. BUDDE [Missouri]: I am very glad to hear this proposal and the actual idea. I am highly in favor of it. However, as a person concerned with the resources of one of the most inland states in this country, I am sorry that it is limited to the extent that it is to high yield coastal areas. We do have pulp mills being built on inland streams. We have chemical plants and petroleum refineries being built on the interior of the country polluting our inland streams. We have governmental agencies dedicated to the proposition that there shouldn't be any streams any more, one dam and a hundred miles, and another hydrodam and another one, thereby eliminating entirely a valuable and unique habitat which cannot be recreated in any way by man. I think I would like to see this thing extended not just to the coastal areas, but over the entire country and all of our unique and valuable areas included in this type of proposal.

MR. POUGH: I think you have a valid point, and this is only just a beginning. If this kind of voluntary cooperation proves to be practical, and I am going to take this up with the American Petroleum Institute and all of the big oil companies, and if they show a little bit of cooperation, we will move on to the Pulp and Paper Manufacturers Institute, the Manufacturing Chemists Association, and see if we can't work it out. The alternative is what was done in Britain where there is complete over-all planning and no industry can locate anywhere except where it is agreed is a good place. In Britain they carry it much farther. They simply decide the town is big enough and has no more land or greenbelt—they don't want to run out of greenbelt—and they simply tell a company like General Motors, "If you want land for a plant, well, you will have to put it somewhere else, because you are not going to release any more land for housing." Certainly, my proposal is the first preliminary. If we don't put these things in their appropriate places, and I would appreciate suggestions from a lot of you. Take the Indiana Dunes. There is a lot of flat country in Indiana that could be reached either by canal dug in from the lake and the harbor without destroying a unique area. I think the possibility is there that it could be done. We've got to get a willingness on the part of industry to cooperate and not that, if one fellow doesn't do it, the next one will. They are all looking for competitive benefits, and say, "We might stay out, but how about the next fellow? We can use the place just a little bit better than the other place, but if a competitor comes and takes it he has an advantage on us." Maybe there isn't any answer to it except zoning, which puts everybody on an even basis, but let's try this first.

MRS. JAMES: Mr. Pough, how much advertising do you do in this respect? I think an advertising campaign would do a great deal in making public opinion alert to the needs of conservation. Now, if one of these big oil companies could be sold on the idea of conservation and then make a big advertising campaign out of this, I think it might do a great deal. I know that they certainly have an understanding of advertising. Couldn't they be brought into the fight with us because it would be to their advantage and it does seem that it would be a good advertising gimmick for them?

MR. POUGH: Well, that is an excellent suggestion, and I thought the Shell people would be very vulnerable to that argument because as you know, it is a world-wide corporation, and everywhere around the world except the United States, they use nature as the theme of their advertising. Their advertisements in Britain have been so fine, the publisher has collected them and put out books of Shell advertisements because they cover the whole gamut of nature, marine life, bird life, wild flowers, and so forth. I am not through opposing Shell yet on this Delaware site, and my colleagues in the World Wildlife Fund, Prince Phillip of Britain and Prince Bernard of the Netherlands, said they would see that I saw the top directorate in Britain and Holland if that would help. Eighty per cent of this stock in American Shell is actually owned and controlled abroad, which makes it a little sensitive to American public opinion. We have other ways of fighting them, and I just hope we have enough so that they will decide it isn't worth fighting and will pick another site. Thank you for your suggestion.

MR. GREENWAY [Saskatchewan]: I think every now and then we get a paper in our conference that is rather outstanding and throws out a great challenge to all of us, and I think Mr. Pough's paper today was in that caliber, and his people have obviously thought through this problem and are now working along a very solid path, and I believe that it is going to be a very effective way of getting at a solution of our coastal areas and to get them set aside and advertised. I was wondering, Mr. Pough, if you have taken your paper and offered it to the Wall Street Journal and to some of the larger engineering magazines? I think that they should be reading it as well as the people here at this conference.

MR. ROLAND CLEMENS [New York]: I think Mr. Pough made a fine presentation in his stimulating introduction to an important area, and I would like to add two comments: One point is that these fights are a stage in our growth, in our sophistication, and they are not altogether sterile. I have in mind particularly the Narragansett Bay fight, which he mentioned. In this case, it led to the U. S. Fish and Wildlife Service being requested to provide a detailed biological survey of that bay, and we can all take advantage of these scientific investigations by passing the information around. My copy of the Narragansett Bay biological report moved up and down the Atlantic coast several times to help our people get ideas. Now, the other point I want to make is perhaps industry is not our only threat to these resources, and I have in mind the fact that the wildlife profession itself, because it is so narrowly oriented is by way of becoming a threat to the perpetuation of some of our better salt marshes, because of a tendency to impound these areas and turn them into sweet water marshes instead of leaving them as tidal marshes. This is a vital problem the biologists have, the responsibility for deciding whether the long range interests of the public in the productivity of a salt marsh is not greater than the short range advantage of turning that salt marsh into an area that might carry a few more ducks.

A VOICE: I would like to ask Mr. Pough what seems to be the secret of the success of the Nature Conservancy in Britain? There must be pressure there.

MR. POUGH: Well, one of the secrets of success is that the Nature Conservancy is a government corporation operating under the Privy Council with very wide broad powers and great freedom, and it is controlled by scientists. It is a remarkable organization. I asked Mr. Nicholson, the director, once how it was governed and run and who sort of checked how they spent their money. Well, he said, "We have a governing body, but since we were started, the governing body has never met. They simply appropriate the money for our program, and our scientific board really runs the organization. The theory, I think, of the politicians is that if these men who are the outstanding men in many scientific fields, biological fields in Britain, don't know what they are doing with money and this program, Britain is a lot worse off than just wasting a little money. In other words, the scientists in Britain have a lot more prestige and there is a greater tendency on the part of the public to say, "If those fellows don't know the answers, who does? Let us trust them and give them power and let them go-ahead." In this country the Nature Conservancy is just a private organization, maybe paving the way some day for becoming an arm of the government but it is a long way from it.

MR. FISHER: We have one more, and I am afraid I will have to move on.

MR. BURNAP: I would like to second the remarks of the person who expressed what I was about to say concerning the threat that seems to be developing in the wildlife profession and conservationists regarding turning the tidal marshes into sweet water marshes, and secondly, I would like to express that—some of you may well realize it—that while industry poses the biggest threat, that both housing—both permanent housing and summer homes—and recreational developments, also pose a very serious threat. They locate them at the site of a marsh, and that kind of threat has been most serious in the Northeast. I think it is extremely important that we should offer a realistic approach in this area and in the recreational field, also, in delineating what areas should be kept free from development.

PAPER MILL POLLUTION IN PUGET SOUND

A. F. BARTSCH

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A difficult water pollution problem has existed in Puget Sound for many years. In an effort to find a solution, the State of Washington asked for enforcement action by the U. S. Department of Health, Education, and Welfare under provisions of Section 8 of the Federal Water Pollution Control Act. As a result of this request, a conference under the terms of the Act was held in January 1962 at Olympia, Washington, to determine the pollution status and remedial actions needed. It was concluded that measures taken to date by some of those contributing pollution to the waters of Puget Sound and the Strait of Juan dé Fuca have not been sufficient to control the pollution, and that delays have been encountered in taking corrective actions. Seven pulp and paper mills were cited, in particular, as the principal sources of pollution that need correction. The conferees then recommended that a joint action program to bring about the abatement of the pollution be undertaken by the State and Federal Governments.

Puget Sound is a body of water tributary through the Strait of Juan dé Fuca to the Pacific Ocean (Figure 1). It drains about 13,000 square miles of land. The water area of the basin is approximately 2,000 square miles. Many rivers, streams, canals and lakes drain from the east, south and west into the Sound and into the Strait of Juan dé Fuca.

The pulp and paper industry has existed in Washington since before the turn of the century and has grown to a prominent national position as a producer of pulp wood, pulp, and paper. Most of the State's mills are located in the Puget Sound area, but seven, utilizing mainly the sulfite base process, contribute the largest percentage of the total pollution. They are located at Bellingham, Everett, Anacortes and Port Angeles, Washington. In terms of oxygen consumption, the more than 187 million gallons per day of wastes they discharge to Puget Sound are equal to the untreated sewage from more than eleven million persons.

The State's request for assistance in connection with this problem was the result of a long and inconclusive effort by the State to bring about the control of pollution from these sources. The conference records that, as early as 1940, efforts were undertaken by the State authorities to seek an equitable solution to the industry's waste disposal problems. Since May 1961 there has been a continous effort by

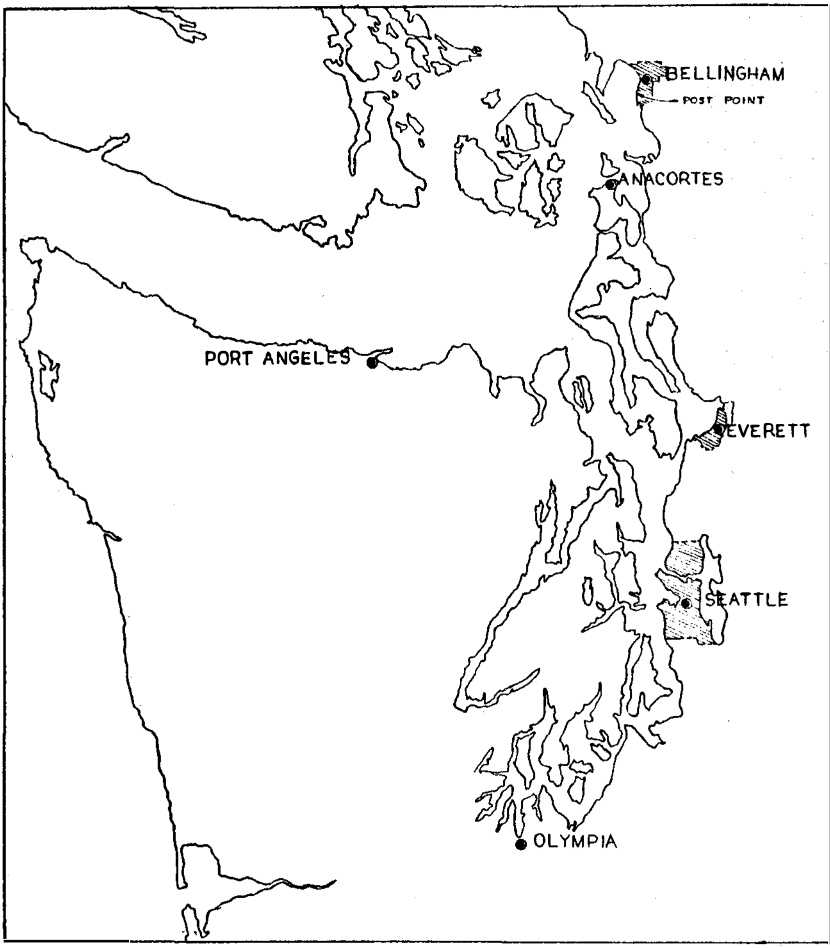

Figure 1.

the State to develop and specify waste disposal permits under which the mills' operations will not adversely affect water quality. In December 1962 permits were issued by the Washington Pollution Control Commission which, in effect, require immediate mill action on removal of suspended solids wastes, while postponing final consideration of sulfite waste liquor disposition until water quality conditions in the affected areas can be ascertained through field study.

STUDY PROGRAM

The study program on Puget Sound, growing out of the conferees' recommendation has been under way since April 1962. It includes field research and related studies at the four specified locations where pulp and paper mill wastes are discharged to the Sound waters. In developing the study plan, assistance was freely given by a Puget Sound Technical Coordinating Committee consisting of members from State and Federal agencies having responsibilities or interests related to water resources of the area. Appointments to the Committee were made so as to assure that knowledge, technical skills and other pertinent resources of the region can be brought to bear on the problem.

The over-all objective of this work is to determine the effects of the mill wastes on water quality, water uses, and the marine environment. The technical program consists of four interrelated elements: (a) inplant surveys to determine the origin, nature, and strength of wastes; (b) oceanographic studies to determine their distribution, dispersion, and persistence; (c) biological and chemical studies of the wastes and their effects on the marine environment; and (d) economic studies on the growth possibilities for the area, the timber and other resources.

Both State and Federal personnel are joined together in teams for unified attack on each phase of the program. At present, twenty-nine persons, including a number with highly specialized skills, have been incorporated with the effort on the Federal level. This number will likely grow to thirty-five or more next year. This total effort, spread over a two and one-half year period, is greater than has ever been brought to bear on the pollution problems of this industry any place in the world.

In-Plant Surveys

In-plant surveys are now getting under way, and one has been completed thus far. Although initial delays had been encountered in this phase of the program, a working agreement has now been developed for cooperative studies in some of the mills and on adjacent waters of the Sound.

The principal objective of the in-plant surveys is to more precisely identify each mill and characterize it as fully as possible as a source of pollution. Wastes from each process in the plant are sampled separately so that their strengths and character can be compared and the most offensive waste sources identified. Wastes are measured qualitatively and quantitatively and checked against production volume so that the data may have real meaning, can be projected to other production levels, and can be compared with other mills. Waste character is examined in the light of the raw materials used which may have considerable impact on the nature of the wastes. The data gathered in this phase of work will permit developing a materials balance for the total process.

Finally, the individual wastes and the consolidated wastes that leave the plant will be characterized as fully as practicable. This effort will include physical and chemical analyses and bioassays with fish and other marine organisms. Information so obtained will permit anticipating the distribution, strength, and effects of the pollutants once they are discharged into the Sound. This information, then, lays the groundwork for the oceanographic studies.

Each mill will be surveyed for a 72-hour period on three separate occasions. Samples will be composited on a 24-hour basis and analyzed, and then these samples mixed for a 72-hour composite. The resulting data will be an adequate reflection of the character of the mill and its waste-producing capacity.

Oceanographic Studies

Once the waste load from each mill is known as a result of the in-plant surveys, the oceanographic studies will: (1) determine the dispersion, travel and persistence of sulfite waste liquor and other wastes from the mills in relation to currents and water movements during various seasons of the year, phases of the tide, and mill operations; (2) define sludge deposit areas, depths, and their nature; and (3) establish light penetration and light scattering characteristics in the vicinity of the mill outfalls.

For this phase of the project there has been assembled a staff of seven, equipped with modern oceanographic equipment. Initially, 38-foot and 65-foot vessels were chartered but present and future cruises will utilize the 45-foot Public Health Service vessel, *Harold W. Streeter,* built for this purpose at Bellingham, Washington.

As of January 1963, 17 extensive field trips in pursuit of these objectives have been made. Eight have been in the Everett area, two in the Bellingham area, two in the Anacortes area, and five in the Port Angeles area.

Studies in the Everett area to date show that sulfite waste liquor from a submarine diffuser outlet can be found at concentrations greater than 5 ppm[1] 10 nautical miles to the south, 17 miles to the north, and 13 miles to the northwest. A tendency for sulfite waste liquor to stratify was noted at different depths, depending on the density of the receiving waters. Concentric about the lines of high

[1]Pearl Benson Index.

sulfite waste liquor are isopleths of low dissolved oxygen and, to a lesser extent, low pH. At the depth of greatest oxygen demand and greatest sulfite waste liquor concentration, there is an excellent correlation of sulfite waste liquor concentration with dissolved oxygen concentration. This correlation applies to varying degrees at depths above and below this level.

Of the two cruises completed at Bellingham, one was concerned with current measurements, the other with water quality. Most of the future work in Bellingham will be concerned with current studies and water quality north and east of Post Point. This area has been selected for cencentrated effort because the University of Washington has recently issued a volume of data listing observations of temperature, salinity, dissolved oxygen, sulfite waste liquor, and phosphate for Bellingham Bay west of Post Point. These data were collected over a 12-month period and their availability makes requirements for further observations in the larger area less urgent.

Current studies to date give a preliminary indication of a clockwise circulation in the Bay which essentially follows the bottom topography. Because the outfalls in the Bellingham waterway are recessed, there is little chance for initial rapid dispersion and dilution. Plans are now being developed for jointly using the current meters in possession of the University of Washington and the Public Health Service, so that by having 17 in the water at one time, the water movements and net transport of Bellingham Bay can be defined more precisely.

The results of several float studies and partial examination of dye released at Port Angeles indicate a complex current system. There appears to be a net movement toward the west end of the harbor at depths along the south shore with a net movement outward, or toward the east, at the surface most of the time. At the west end of the bay, there is a considerable amount of opaque, white wash water resulting from pulp washing. There are also large quantities of floating materials which have broken off from the bottom, but sulfite waste liquor concentrations in this part of the bay are generally fairly low. Near one mill at the east area of the bay, there are extremely high sulfite waste liquor concentrations. The distribution of sulfite waste liquor in the Bay changes radically with time, as a function of tide change and wind velocity.

Preliminary observations indicate that in the vicinity of the mills, fiber, bark and other solids of mill origin are deposited on the bottom and contribute to sludge bed formation. Such beds blanket the bottom but decrease in thickness with distance from the point of origin. Not only do such sludge beds inhibit the production of a normal fauna for the area because of the physical suffocation of the habitat, but they also provide an anaerobic environment in which toxic hydrogen sulfide is produced. Several procedures involving scuba diving and core sampling will be used shortly to map the sludge areas, trace the vertical profile, and ascertain sludge composition.

Monthly oceanographic observations in the four study areas will be made so as to delineate the water movements as fully as possible over the full range of tides and seasons. To provide for more effective collection of meaningful oceanographic data within the two-year duration of the study, the most modern sampling, sensing, sample processing and recording equipment is being obtained. Among items now available and on order are a shipboard gas chromatograph, salinometer, recording fluorometer, recording dissolved oxygen meter, and several Richardson current meters. Under present arrangements, data processing is being done at the University of Washington Computer Center.

Biological and Chemical

Biological and chemical studies will further characterize the wastes and determine their effects on the marine environment. The principal wastes of concern are the used waters from barking, pulping, washing, bleaching, and paper making. In general, they are responsible for: (1) formation of sludge beds, (2) oxygen depletion, (3) toxic action, and (4) unsightly conditions. Determining how and to what extent they exert these actions is the function of the biological and chemical studies.

The problem is approached so as to detect and measure directly the influences of pollution on fish and shellfish resources and to measure them less directly by evaluating the changes wrought in the environment. Because anadromous fishes of several kinds use the waters near the mills as migration and feeding areas, data are gathered on fishkills that occur, on episodes of fish distress apparently attributable to pulp mill wastes, and on the extent to which fishes actually invade the areas and could therefore be vulnerable. Here as well as at other mill sites, live box bioassays using down-stream migrant salmon, herring and crustacean fish foods will be made to ascertain the occurrence, intensity and distribution of toxic conditions.

Concurrently, laboratory bioassays will be made with oyster and clam larvae using Pudget Sound samples collected at suspect stations near the mills. The samples will be flown to the laboratory by seaplane to shorten the time from collection to sample processing. The bioassay technique will be that used by the State of Washington Department of Fisheries (Lindsay, *et al.,* 1960) which uses yield of embryos, their size and abnormal development as criteria of toxicity.

Claims have been made by some oyster growers that oysters that can survive and grow to maturity in waters receiving mill wastes do not fatten sufficiently to be marketable. To shed light on this phase of the problem development of oysters to harvestable age will be followed by placing them in floating rafts and anchoring the rafts at key points in the Sound. In these long-range tests, lasting two to three years, the survival, growth and marketability will be gauged against proximity to the mills, measurable water quality, and other pertinent factors.

A number of less direct biological approaches are being used, each to yield pieces of information which together portray the environmental responses to pollution that are occurring. In each of the four geographic areas, the biological tone of the environment will be detected and measured to determine if the biological populations and patterns have become altered as compared with unpolluted areas. Four times during the year populations of benthic and intertidal organisms will be collected, identified and productivity measured in terms of organism volume per unit of environmental space.

Plans are now under way to mark and release downstream migrant salmon in the Snohomish River near Everett so that the extent to which they inhabit the polluted Inner Harbor down-stream can be estimated from recoveries. Comparable work will be done as necessary at Bellingham, Anacortes and Port Angeles. Distribution of fry, juveniles, adults, and major food organisms will be found by sampling with various devices, including an inclined plane sampler, beam trawl, beach seines, and a purse seine.

Creel census data, historical records, and other sources of information are being scrutinized to add to the growing picture of the anadromous fisheries and their use of tributary streams.

Of great importance is knowing whether pulp and paper mill wastes impair the ability of the Sound waters to produce living matter. Obviously, without an adequate starting point of the food progression, the growth and production of fish and shellfish cannot proceed at a favorable rate. This question of productivity is approached in several ways. On four occasions during the year, glass slides are suspended in the water as a surface on which algae, protozoa and other organisms may become attached. These samples then are processed to determine the species present and numbers of each. Zoo-plankton populations are also sampled with Clarke-Bumpus and Wisconsin-type nets. Results are expressed in terms of numbers and volumes of organisms and species composition. Phytoplankton collections are made utilizing Van Dorn samplers and results are expressed in terms of phytoplankton identification and in pigment (chlorophyll) concentration. In addition, basic productivity will be measured more-directly through use of the C14 technique.

Economic Studies

The specific economic studies now under way or proposed relate basically to the question of the impact of waste treatment, or its lack, on the economy of the area. The problem is approached along two lines. First, because waste treatment or other waste handling may be costly, additional treatment costs are examined. In order to properly measure and interpret their effect, the economic background of the pulp industry must be understood. Second, it is necessary to know the significance of the other uses of the Sound waters receiving the wastes and the relative importance to the region of these various components of the economy. Three studies, carried out by consultants under contract, are now nearing completion. The objective of the first is to describe and analyze the uses and possible benefits for several key in-place uses of water in Puget Sound that may be affected by inadequate water quality. The second will examine the present and historical economic base of both the Puget Sound area and the State and describe the major components of anticipated future change. The third will describe and analyze the Washington wood pulp industry with particular emphasis on the economic relationships of and within the sulfite mills.

CONCLUSION

It is the intent of this program to determine the effects of pulp and paper mill wastes on water quality, the marine environment and water uses. The methods, equipment and skills put to the task are the best attainable. The knowledge obtained will be used to determine what further remedial action is required of the seven mills concerned in the interest of restoring and preserving water quality in Pudget Sound.

LITERATURE CITED

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DISCUSSION

MR. FISHER: Thank you very much, Mr. Bartsch. Now, are there any questions?

MR. GENE KANAGA [Midland, Michigan]: Since 1946, DDT has been used world-wide, and in the last 10 years, about a billion pounds of this material has been put upon this earth and we are now reaping the effects, as Dr. Springer has been pointing out, and the residue is very difficult to decompose. There are a number of other residual materials also on the market, and that is why we have been talking about all these residues. As a member of the chemical industry, however, I would like to point out there are some bright spots in the picture. I haven't heard mentioned the gray tick killers, and other newer classes of insecticides which are readily decomposable and which leave non-toxic residues. In fact, some of the residues are actually components of the human body. It might be interesting to know that this year about 180 million pounds of DDT are being made. This is the level of this particular material being manufactured. It is estimated there will be about 60 million pounds of Malathion made this year, and perhaps close to 30 million pounds of Dymat Number Seven. So, you see, these new insecticides are indeed making inroads into our economy in regards to production, and I think the trends. while it seems like we are on the back roads here with regards to hydrocarbons, this black historic picture is now catching up with us, our future is now in this type of material.

MR. FISHER: Thank you very much.

MR. SPRINGER: Well, I certainly agree this is a commendable trend to develop safer pesticides. However, the problem isn't as simple as might be implied, because we are considering now the entire animal kingdom, practically, when we talk about wildlife, and there is plant life, too. You mentioned two compounds, Malathion, which is considerably safer to warm-blooded animals, certainly, than other chemicals. However, studies have shown it can be very toxic to fish. I didn't cite this example, but a study in Delaware, half a pound of Malathion, which is a standard application for mosquito control, killed one-third of the killi fish. This isn't a natural condition, but it shows the possibilities. Sevin again is safer to vertebrates, but I believe work in New York has shown that this is possibly just as toxic as DDT is to invertebrates, so the point is that we have to be very careful in using this material and try to use them where they will do the job and try not to hurt the other beneficial life that would be exposed to them. This isn't to say they both don't have a place, but they have to be tied in. Thank you.

F. H. LESSER [Delaware]: I would like to make a statement on impoundment as an alternative method for chemical control of insects, and other means to improve wildlife habitat. One fact that many people go on is the belief that we are trying to snap up all forms of marshes, and that is as far from the truth as can be. Most of them are not even suitable for impounding because of the nature of the marsh itself. They are not suitable for the construction of dikes, and also, mosquito control is a most important facet now for supporting these impoundment studies. They are using impoundments upon salt water, and these are mostly used on tidal marshes that are of a much higher nature and firmer bottom which provides a suitable habitat, and another point that many people bring out is that productivity of the marshes provide all the nutrients for tidal estuaries. Well, this has been borne out in many studies, but most of the studies were concentrated along the tidal kick-backs where all the diatoms and what-not that are produced in the inter-tidal zone are necessary for the development of sport fish and good fisheries. There have been very few studies made in the higher tidal marshes that are impounded for mosquito control, and I theorize that possibly these higher marshes not only constitute a large amount of nutrients which are washed into the bay, but also in conjunction, there is the water in the ponds constructed around the edge of these impoundments. They have additional exposed tidal and inter-tidal mud flats that produce an additional amount of nutrients that can be washed into the bay, so until further studies are carried out, possibly these impoundments are producing more nutrients that are washed into the bay than are utilized or retained inside. Thank you.

MR. FISHER: Yes?

MR. RONN [Conservation Foundation]: I was very interested in what Bob had to say about Puget Sound and the area in which it was involving wastes, and I would just like to mention we have some serious situations in the East. I don't know if anybody here knows of any similar studies being carried on in the Penobscot or other rivers. I think we have a serious situation here, too.

MR. FISHER: Thank you. Are there any other questions or comments? If not, I would like to thank the speakers very much for their earnest cooperation in meeting this time problem we have at these large meetings.

PESTICIDES—A NEW FACTOR IN COASTAL ENVIRONMENTS

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AND

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Chemical control of unwanted organisms is not new, actually dating back at least as far as the days of the Greeks. It is only within the last decade, however, that the use of pesticides has increased to the point that they must now be reckoned a significant factor in the environment of fish and wildlife. The era of the new pesticides, principally organic compounds, can be said to have started during World War II with the widespread application of DDT for control of insects affecting man's health and comfort. Soon thereafter this material was being used against agricultural and forest pests, and a host of new pesticides was being developed.

The possibilities of damage to non-target organisms were recognized at the outset, and studies were conducted by the U. S. Fish and Wildlife Service and other Federal agencies, and by various State agencies and private organizations and individuals. Early and generally limited research in coastal environments, or with the animal inhabitants of these areas, was reported by Ginsburg (1945), Sandholzer (1945), Cottam and Higgins (1946), Nelson and Surber (1947), Loosanoff (1947), Tiller and Cory (1947), and Goodrum et al. (1949). A more detailed study was conducted by Springer and Webster (1951). Most of the early work, however, was concerned with inland areas, and it is only recently, with greater awareness and funds, that increasing attention has been focused on our important coastal resources.

During the past five years, the Bureau of Commercial Fisheries, Fish and Wildlife Service, has stressed laboratory investigations of the relationship between pesticides and coastal fish and shellfish. Initially, these studies were conducted concurrently at four regional laboratories with emphasis on separate animal groups in each area. More recently the program has been consolidated in Florida, and separate projects are conducted as the need arises in different geographic locations. Unless otherwise stated, the laboratory findings reported in this paper have resulted from the Bureau's work in Florida (Butler, 1963).

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Today the total area in the United States treated annually with chemical pesticides is estimated to be nearly 200 million acres. Applications to any given tract may vary from as few as 1 every several year for forest insect control to as many as 50 or more a year for adult mosquito control. It is estimated that about 90 million acres are treated annually for chemical insect control (Hall, 1962), and chemical weed control is practiced on 90 million acres of agricultural land alone (Shaw, in press).

In addition, large areas receive applications of chemicals for control of non-agricultural weeds, plant diseases, and other pests. These are not all different acres, however. New areas are continually being treated as the upward trend in pesticide use continues, and as new outbreaks of pests occur. Moreover, treatment is not necessarily restricted to the intended area. Pesticides applied from the air can be carried by the wind, often for miles. Even when they reach the ground they are subject to further movement, some being caught up again by the wind in dust, others being washed away into streams and rivers in solution, or when adsorbed on soil particles. This is in addition to chemicals that are applied directly to coastal marshes and bays for control of mosquitoes, flies, weeds, and other pests.

The persistence of many of the chlorinated hydrocarbon insecticides is well known, but not as well understood is the fact that some may last 10 years or more (Lichtenstein and Polivka, 1959). Until recently, the organic phosphorus insecticides were of little concern in this respect because of the ease with which they undergo hydrolysis and presumably become innocuous. It has been found, however, that even some of these, such as parathion, may contaminate watersheds for as long as 9 months after orchard applications (Nicholson et al., 1962). Analyses show that parathion was transported by runoff and concentrated in lowlands and pond muds.

Whether parathion and other chemicals eventually reach the sea in significant quantities remains to be learned. However, studies by the U. S. Public Health Service show that most of the major rivers sampled since 1957 are carrying at least trace amounts of certain pesticides (Middleton and Lichtenberg, 1960). The presence of DDT—5 parts per billion (p.p.b.) in water, 40 p.p.b. in endemic trout—in a presumably uncontaminated coastal stream in Alaska indicates some possibilities of movement.

The reaction of estuarine animals and plants to pesticides, although sometimes direct and obvious, is more often ill-defined and far from understood. This results in part from the various modes of action of these chemicals. A pesticide may be directly toxic, either over a short or a long period, or it may exert an indirect influence through reduction of lower food-chain organisms or other modification of the habitat. A secondary toxic influence occurs when pesticides applied at low rates are concentrated in successively greater amounts in their passage through the food chain until they reach a level that is poisonous to predatory higher forms of animal life. Considerable species and individual differences exist in tolerance to the various pesticides. Consequently, results are not necessarily predictable on the basis of work with related compounds; usually each chemical must be evaluated.

LABORATORY AND FIELD TOXICITY STUDIES

Phytoplankton

Previous investigations by Ukeles (1960) showed that the floating microscopic marine plants are extremely sensitive to the substituted urea herbicides including monuron, diuron, and neburon and cannot tolerate concentrations as low as 0.5 p.p.b. There has been particular concern that many of the other pesticides might seriously affect this phytoplankton, which forms the broad base of the food chain and is much more important in coastal environments than in fresh water.

Phytoplankton productivity can be measured by adding known amounts of radiocarbon to samples and determining the amount of carbon fixed in the cells after a definite interval under constant light conditions. This technique has been used in the laboratory to evaluate the effects of a large number of the most important chemical pesticides. Most of the chlorinated hydrocarbons, including DDT, heptachlor, chlordane, aldrin, and toxaphene, decreased productivity by 50 to 90 per cent when present at a concentration of 1 part per million (p.p.m.) for 4 hours. The organophosphorus compounds, as a rule, are much less toxic, as are also the herbicides, except for the substituted ureas. For example, at a concentration of 1 p.p.m., 2-4-D and its derivatives had little effect on productivity. The few fungicides that have been tested, however, are as toxic as the chlorinated hydrocarbons.

Crustaceans

Because shrimp, crabs, and other crustaceans are arthropods, like the insects, they understandably are sensitive to many of the chemical insecticides. Concentrations of heptachlor, endrin, and lindane in the range of 0.3-0.4 p.p.b. killed or immobilized half of the adult commercial brown and pink shrimp exposed in 48-hour laboratory tests. Other chlorinated hydrocarbons, including DDT, chlordane, toxaphene, and dieldrin, showed similar effects at 1-6 p.p.b. In the laboratory, paralyzed individuals may live for days or even weeks, but in the struggle for survival in the sea this condition results almost immediately in death.

Juveniles of the blue crab, important not only for its commercial but also for its sporting value, are about 100 times more resistant than shrimp to the chlorinated hydrocarbon insecticides in laboratory tests. The stone crab is intermediate in susceptibility (Butler, 1962).

Few organophosphorus compounds have been tested on crustaceans. These materials show various degrees of toxicity but one, Bayer 29493, (Baytex®),[1] used in mosquito control, is the most toxic pesticide tested to date on shrimp and crabs in the laboratory. Herbicides are of relatively low toxicity to crabs. However, mud crabs, perhaps because of their small size, were irritated by 2,4-D at a concentration of only 1 p.p.b. (Butler, 1962). Few herbicides have been tested on shrimp.

Field studies[2] of DDT as used in aerial mosquito control in tidal salt marshes at rates as low as 0.2 lb/A corroborate the high sensitivity of crustaceans (Springer and Webster, 1951; Springer, 1961). Isopods and amphipods were nearly extirpated and showed no population recovery even 1 to 2 years later. Prawns, or grass shrimp (*Palaemonetes*), used as fish bait, were somewhat less susceptible. Populations of blue crabs were reduced 10 to 40 per cent when exposed to single treatments of DDT at 0.3 lb/A and 95 to 97 per cent when these treatments were repeated 3 to 10 times a year for several years. Fiddler crabs were generally more resistant than blue crabs. George et al. (1957), however, obtained contradictory findings on the relative susceptibility of fiddler and blue crabs to DDT.

Field studies with other chemicals showed BHC (100 per cent gamma isomer equivalent) and dieldrin to be more toxic than DDT to blue and fiddler crabs (Springer, 1961). An experimental treatment of 0.3 lb/A of dieldrin for greenhead fly control killed many of these crustaceans (Jamnback and Wall, 1959), and a treatment of 1 lb/A for sandfly control caused complete annihilation without any evidence of population recovery for at least the next 4 months (Harrington and Bidlingmayer, 1958).

Because of their habits and low toxicity tolerance, the commercial shrimp are particularly susceptible to pesticidal poisoning. After hatching in offshore waters the young, which usually are more sensitive than the adults, spend several months in the upper reaches of estuaries and bayous where they are nearer most sources of pesticidal pollution and, thus, doubly vulnerable. Extensive contamination of the environment could have serious repercussions since, collectively,

[1]Reference to trade name does not imply Government endorsement of a product.
[2]Throughout the paper the field applications referred to were made in accordance with recommended practice or registered use, unless otherwise stated.

shrimp make up the Nation's most valuable fishing product in terms of revenue yield (Power, 1962). A number of shrimp in an estuarine stream of coastal South Carolina died after heavy rains presumably washed in heptachlor applied 6 days previously to adjoining land at 0.25 lb/A for imported fire ant control. This stream occurs in an area upon which 60 per cent of the State's shrimp production depends (personal communication, Robert Lunz, April 10, 1962). Also, shrimp in bait pens along the Florida and Texas coasts were killed by DDT or BHC applied for mosquito control (deSylva, 1954; Chin and Allen, 1957).

Mollusks

Pesticidal effects on oysters, clams, and mussels may be less obvious. The adult forms being sedentary cannot flee from pesticide-contaminated areas. Their reaction in the face of high concentrations is to close their shell, sometimes for as long as a week or two, thereby stopping feeding and growth. Metabolism is increased during the summer, however, forcing them to open sooner than they would at lower temperatures, and to possibly acquire a lethal dose. At lower concentrations, oysters may fail to pump water or grow at their usual rate, even though they stay open and feed to some extent (Butler et al., 1960).

The chlorinated hydrocarbons are the most toxic pesticides tested in the laboratory. They cause a 50 per cent decrease in shell growth in 96 hours at concentrations ranging from 0.007 to 0.5 p.p.m. depending on the chemical used. Lindane, organophosphorus and carbamate insecticides, and herbicides were much less toxic. Loosanoff et al. (1957) found that larvae of oysters were considerably more susceptible than adults to DDT; all larvae died in 96 hours at 1 p.p.m.

When oysters, whose growth rates had been decreased by pesticides, were returned to unpolluted sea water, they recovered their normal growth rates within 2-4 weeks. The length of the recovery period had no apparent relation to the severity of the toxic effects of the more than 30 different chemical pesticides tested.

In the field, single or repeated applications of DDT at dosages of 0.2-0.8 lb/A (and experimentally up to 1.6 lb/A) and of aldrin at 0.2 lb/A for mosquito control in tidal salt marshes had no apparent adverse effect on adults of various species of snails and mussels (Springer and Webster, 1951; Springer, 1961). Populations of salt-marsh snails (*Melampus bidentatus*) actually increased after DDT treatment, possibly because of control of some limiting factor.

A 0.3-lb/A experimental application of dieldrin for greenhead fly control did not appear to harm snails (Jamnback and Wall, 1959). Three months later nearly all of the horse mussels in the treated plot were dead, but a significant amount of halogenated hydrocarbon was not found in the tissues of living mussels, either shortly after treatment or 5 months later. There were no visible detrimental effects on snails and oysters from a 1-lb/A application of dieldrin for sandfly control (Harrington and Bidlingmayer, 1958).

Fish

The two species of marine fish studied in the laboratory show a relative pattern of response to the various groups of pesticides similar to that exhibited by the plankton, crustaceans, and mollusks. They are somewhat more resistant than shrimp. Half of the juvenile striped mullet tested were generally killed in 48 hours by chlorinated hydrocarbons at concentrations ranging from 0.0004 to 0.007 p.p.m. BHC, Mirex, Kepone,® lindane, and methoxychlor were the principal exceptions, requiring concentrations from 10 to 100 times greater. The longnose killifish was slightly more resistant than the striped mullet.

DDT at 0.2-0.6 lb/A for mosquito control caused considerable distress (but apparently low mortality) among killifishes and tidewater silversides in tidal salt marshes, whether applied only once, or monthly for 3 months. Fairly heavy losses occurred at 0.8 lb/A, particularly in shallow ponds not subject to regular tidal flushing (Springer and Webster, 1951). Dieldrin at 0.2 lb/A (experimental) killed many fish in salt marshes (Ginsburg and Jobbins, 1954) and at 1 lb/A, as registered for sandfly control, caused substantially complete mortality (Harrington and Bidlingmayer, 1958). Repopulation by some but not all species was completed 10 weeks later. No mortality among fish in salt marshes was observed from applications of BHC (100 per cent gamma isomer equivalent) and aldrin, each at rates of 0.2 lb/A (Springer, 1961). A treatment of 0.5 lb/A of malathion killed a third of the killifish held in artificial containers (Darsie and Corriden, 1959).

The potential significance of pesticides to certain fin fish is illustrated by the fact that large numbers of young menhaden concentrate in restricted parts of estuaries during their first year of life (June and Chamberlin, 1958). The annual commerical catch of this species in the United States exceeds that of any other fish (Power, 1962). Mullet, spot, and other species sought by both commercial and sport fishermen spend part of their lives in tidal estuaries. The killifishes, so common in coastal marshes, aid in control of the same mosquitoes for which some pesticidal programs are intended, and, in addition, are taken for use as fish bait.

Reptiles and Amphibians

Diamondback terrapin in tidal streams were not outwardly affected by mosquito control programs involving application of DDT at experimental rates as high as 1.6 lb/A and of BHC (100 per cent gamma isomer equivalent) at 0.2 lb/A (Springer, 1961). Similarly, leopard frogs in brackish meadows survived treatments of BHC (100 per cent gamma isomer equivalent) at 0.2 lb/A and dieldrin at the experimental rate of 0.2 lb/A.

Birds

Birds, too, apparently were not directly affected by BHC (100 per cent gamma isomer equivalent) and aldrin at 0.2 lb/A and experimental treatments of DDT at 1.6 lb/A and of dieldrin at 0.25 lb/A (Springer, 1961). However, a week-old clapper rail died about 2 days after application of DDT at 0.3 lb/A (Springer and Webster, 1951). Analysis of the tissues showed 112 p.p.m. of DDT, which probably was obtained through consumption of poisoned fiddler crabs. Fiddlers that died following repeated applications of DDT at 0.2 lb/A contained 2.2-46 p.p.m. of DDT (Mills, 1952).

These crustaceans compose as high as 90 per cent of the summer diet of clapper rails in New Jersey. Obviously, any sizable reduction in crustacean numbers because of pesticidal applications could have a profound indirect influence on the population and production of clapper rails. Other birds, including various species of herons, gulls, terns, swallows, and sparrows, increased or decreased in abundance in accordance with the availability of food that remained after mosquito control treatments. Ginsburg and Jobbins (1954) reported some birds were killed within 3 days after an experimental application of dieldrin in granules at 0.2 lb/A. Whether birds eat these granules is unknown.

That birds inhabiting coastal areas are becoming contaminated with pesticides is shown by the results of collections of waterfowl along the Gulf in Texas in 1961 (Crabtree, 1963). Over half of the individuals examined were carrying residues of DDT and related compounds in their bodies. Although they probably picked up some pesticides during their migrations south and north, it is entirely conceivable that some came from chemicals that were applied for mosquito control in the area or that washed or drifted in from other areas. The effects of these pesticidal burdens on bodily processes are only poorly understood. However, recent studies in California show that DDT and dieldrin applied as seed treatments for control of rice insects significantly reduced the survival of young pheasants (Hunt and Keith, 1963).

Mammals

The few studies that have been made show that mammals in coastal marshes were not outwardly affected by chemical applications for mosquito control. Marked meadow voles and rice rats survived treatments of BHC (100 per cent gamma isomer equivalent) at 0.2 lb/A and dieldrin at the experimental rate of 0.2 lb/A (Springer, 1961). No affected mammals were found after experimental applications of DDT as high as 1.6 lb/A (Springer and Webster, 1951). Stearns et al. (1947) found that spraying of DDT at 0.2 lb/A and Paris green at experimental rates as high as 4 lb/A did not appear to harm muskrats.

SPECIAL PROBLEMS

Chronic Toxicity

Ordinarily, because of rapid dilution rates, high pesticidal concentrations are not to be anticipated in estuaries. Therefore it is of interest to note the reaction of typical animal inhabitants to continuous exposure to low levels. Juvenile clams were subjected to DDT (1 p.p.b.) and dieldrin (5 p.p.b.); oysters and mussels were subjected to aldrin (2 p.p.b), malathion (2 p.p.m.) and toxaphene (50 p.p.b.); and spot were subjected to dieldrin at concentrations of 0.1, 0.01 and 0.001 p.p.b. Exposure periods ranged from 3 to 6 months. Animals were maintained in running sea water to which the pesticide was continuously added. Under these conditions it was found that mortality and growth rates were nearly identical in experimental and control groups. Experimental oysters became sexually mature and spawned at the same time as the controls.

The unfiltered sea water supplying these aquaria contained planktonic larvae. Large numbers of these benthic animals, including at least 25 species in 7 phyla, set fortuitously and grew equally well in experimental and control aquaria.

However, not all of the observations were so reassuring. There was definite evidence of distortion of the vertebral column in many of the experimental, but in none of the control fish. Unfortunately, growth rates of both experimental and control spot were appreciably lower than expected, perhaps because of an inadequate food supply. This work is being repeated and expanded to clarify the results.

Resistance

There is a growing body of evidence to show that insects and some freshwater vertebrates, such as mosquitofish (*Gambusia affinis*) (Vinson et al., 1963) and cricket frogs (*Acris*) (Boyd et al., 1963), are developing resistance after exposure to pesticides. Presumably, this occurs through the breeding of resistant individuals. It was of interest, therefore, to determine if any resistance had developed in the mollusks and fish used in the chronic toxicity experiments described in the previous section. When these experimental oysters were subjected again to toxic concentrations of the several pesticides, growth rates immediately were halved and it was obvious that no resistance had appeared.

However, the spot again reacted differently. In a test with dieldrin, all untreated control fish from the long exposure experiment died in 24 hours when exposed to a presumed minimum lethal concentration, whereas only 20 per cent of the fish previously exposed to low concentrations died. Whether this acquired resistance is permanent or temporary will be studied in future tests.

Biological Concentration

The mechanisms for concentrating pesticides in the estuarine environment are being investigated now under controlled laboratory conditions. The well-known ability of the oyster to extract and accumulate heavy metals and petroleum products present in only trace quantities in the sea water makes them especially suitable as test animals. Oysters have been observed to concentrate zinc, for example, at a level about 170,000 times that in the surrounding water (Chipman et al., 1958).

Oysters exposed to DDT at 0.5 p.p.m. in relatively small aquaria were found to remove more than 50 per cent of the chemical from the surrounding medium within 6 hours and 96 per cent in 2 days. Under these conditions, much of the DDT is adsorbed in the intestinal contents and excreted. Fecal deposits were found to have approximately 35 times the concentration of DDT originally present in the water. A relatively large percentage of the DDT was also retained in the oyster body tissues. Experiments are continuing to determine under what conditions, and for how long, the oyster will retain this pesticide.

The fact that the oyster and other filter-feeding bottom forms, such as mussels and clams, may concentrate and fix these chemicals in their fecal deposits is a matter for additional concern. The non-selective bottom feeders, such as the marine worms, are important links in many of the estuarine food chains and may, in turn, accumulate the pesticides to an extent lethal to their predators, including the fish and crustaceans that provide food for man and certain birds that are taken as game and later eaten. Thus, in the sea, there is the possibility of a continuous recycling and concentration of the more stable pesticidal compounds until they pose a real threat to man's own welfare. This problem has received little attention in marine environments so far. However, large biological build-ups of pesticidal residues through the food chain have been noted in freshwater areas. Original applications of 0.014-0.02 p.p.m. of TDE (DDD) in water were eventually concentrated in fatty tissue to peak levels of 2500 p.p.m. in fish and 1600 p.p.m. in fish-eating birds (Hunt and Bischoff, 1960).

Habitat Modification

The most obvious effects of pesticides are toxicological. But there are indirect effects that can be at least as destructive. One of these, discussed previously, is reduction of lower food-chain organisms. Another is modification of the vegetative environment by herbicides. Beaven et al. (1962) showed that aquatic weed control programs, such as those for Eurasian watermilfoil (*Myriophyllum spicatum*), will kill oysters, clams, and possibly fish and crabs when large amounts of decaying vegetation deplete the oxygen content of the water, producing an anaerobic condition. Non-specific herbicides applied for control of certain weeds may also kill desirable plants in the treated area or outside of it when transported by currents.

SOLUTIONS

Recognition of the persistence of pesticidal residues in the environment and the sensitivity of non-target animals has greatly stimulated the search for less hazardous control measures. The introduction of any foreign chemical agent into the environment constitutes some degree of pollution that is fundamentally undesirable. Our overall objective must be to devise controls that are more specific, and here there are signs of progress.

Many biological control procedures are inherently specific. Methods now being explored include development of species-specific bacterial diseases and wider application of sterilization techniques, such as those used successfully in controlling screw-worm populations.

Specificity in chemical control is needed also. Pesticides are available that are definitely less hazardous to non-target animals than those now in use, even though some of them may be less easily applied and possibly more expensive. For example, ryania could be substituted for toxaphene in the control of the cane borer in Mississippi delta sugar fields. Similarly, certain organophosphorus compounds kill mosquitoes at levels that are not known to be toxic to fish or to tadpoles (Mulla et al., 1963). These compounds also reduce the probability of biological concentration because, as a rule, they hydrolyze rapidly. This characteristic of rapid disappearance is important in preventing damage to non-target species. Powerful sex attractants may bring the pest to the poison without endangering other species. Baits that are attractive to the target organism and less so to other animals also can be useful; such baits are being tried for imported fire ant control.

Most promise for effective pest control with least damage to wildlife and fish lies in carefully planned integrated programs. It has been shown that a well-designed attack that includes the careful use of pesticides with the use of other methods can provide control that is as effective, safer, and less costly than chemical applications alone (Pickett, 1961). We look forward with confidence to the development of techniques that will more adequately preserve our coastal environments.

SUMMARY

Pesticides are used so widely now that they must be reckoned a significant factor in the environments of fish and wildlife. Increasing attention is being devoted to study of their effects on important coastal resources. Chemicals may be directly toxic or exert an indirect influence through reduction of food-chain organisms or modification of the habitat. Another mode of action is biological concentration in successive food-chain organisms. Information is summarized on the known effects of pesticides on coastal life from plankton to mammals. Toxicity varies greatly among different organisms and chemicals. Some marine forms appear to be unaffected by recommended or registered pesticidal applications while others are susceptible to poisoning at concentrations of a fraction of a part per billion. Use of less persistent chemicals that are more specific for individual pests and less toxic to non-target organisms offers promise for the future, particularly when integrated with physical and biological methods of control.

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TECHNICAL SESSIONS

Wednesday Morning—March 6

Chairman: W. Leslie Robinette
Chief, Section of Upland Ecology, Bureau of Sport Fisheries and Wildlife, Denver, Colorado

Discussion Leader: Norman V. Hancock
Chief, Game Management, Utah State Department of Fish and Game, Salt Lake City, Utah

FOREST AND RANGE RESOURCES

A STATISTICAL EVALUATION OF FACTORS INFLUENCING AERIAL SURVEY RESULTS ON BROWN BEARS[1]

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Alaska Department of Fish and Game, Anchorage, Alaska

Aircraft are becoming increasingly important in assessing the abundance and status of big game species. While past studies have demonstrated many applications of aerial surveys, these studies have given little consideration to animal behavior patterns, observer abilities and other factors which may bias biological interpretations. Riordan (1948), Buechner *et al.* (1951, Banfield *et al.* (1955) and others have enumerated a number of aerial survey variables and suggested their possible influence on survey results. However, with the exception of limited data presented by Edwards (1954), Buechner *et al.* (op. cit.) and Sumner (1948), only subjective evaluations

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have been made of such variables. Generally, these workers found aerial counts low compared to ground counts. Bevan (1961), reporting on an experimental design testing the variability of observers in estimating numbers of spawning pink salmon (*Oncorhynchus gorbuscha*) found a variance of 50 per cent between estimates and concluded that even for trend analysis, observations should be limited to one observer.

In parts of coastal Alaska, concentrations of brown bears (*Ursus arctos*) along streams during the spawning migrations of salmon (*Oncorhynchus* sp.) lend themselves to population analysis by aerial observation. However, analysis of data from surveys conducted over the past four years revealed inconsistencies in the number and composition of the bear populations studied (Erickson, 1961). The discrepancies appeared to be attributable to factors such as: differences in the abilities and experience of observers, the time of day and dates the surveys were flown, weather conditions, fish abundance, and other considerations. Similar perplexing inconsistencies have plagued aerial surveys of other big game species in Alaska.

The purpose of this study was to provide a statistical evaluation of a number of measurable survey variables as tested on a brown bear population.

The study was carried out between July 31 and August 16, 1962, in the Chignik-Black Lakes drainage of the Alaska Peninsula (Figure 1). This drainage encompasses approximately 600 square miles and exhibits alpine and sub-alpine areas which typify Alaska Peninsula eco-types (Figure 2. These types are predominantly open tundra at the southern tip of the Peninsula trending to more dense alders, (*Alnus* sp.) willows, (*Salix* sp.) and cottonwoods (*Populus balsamifera*) at the base of the Peninsula. The drainage exhibited other attributes suiting it particularly to the study objectives. Past surveys had shown the system to consistently contain a sizable bear population. Relatively accurate salmon catch and escapement data were also available for the system (Alaska Department of Fish and Game Annual Reports). The year-to-year consistency of the latter was especially advantageous to fulfilling study objectives since an aberrant situation during the study would raise questions as to the applicability of the findings to future and past surveys.

METHODS AND PROCEDURES

The primary design of the study consisted of three replicates of a 3-by-3 Latin square testing for differences between observers, dates, and times of day. One pilot and aircraft were used throughout the

Figure 1. Map of Black-Chignik Lakes Study Area

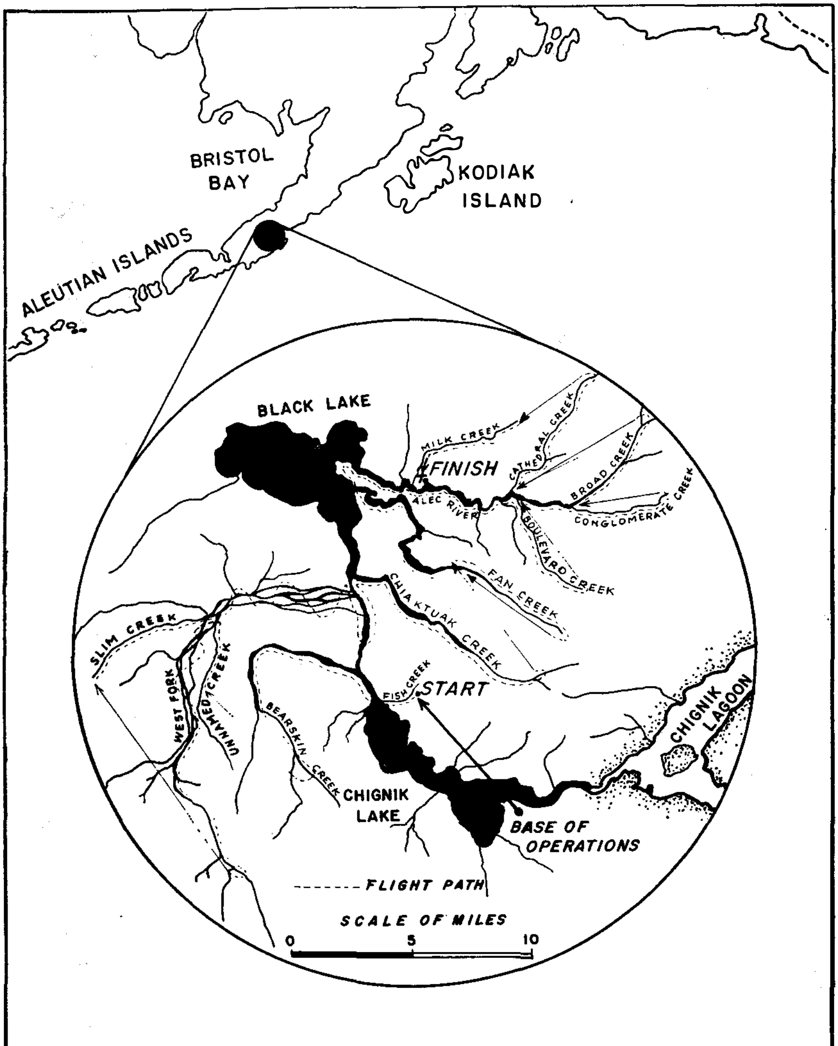


Figure 1 Map of Black-Chignik Lakes Study Area.

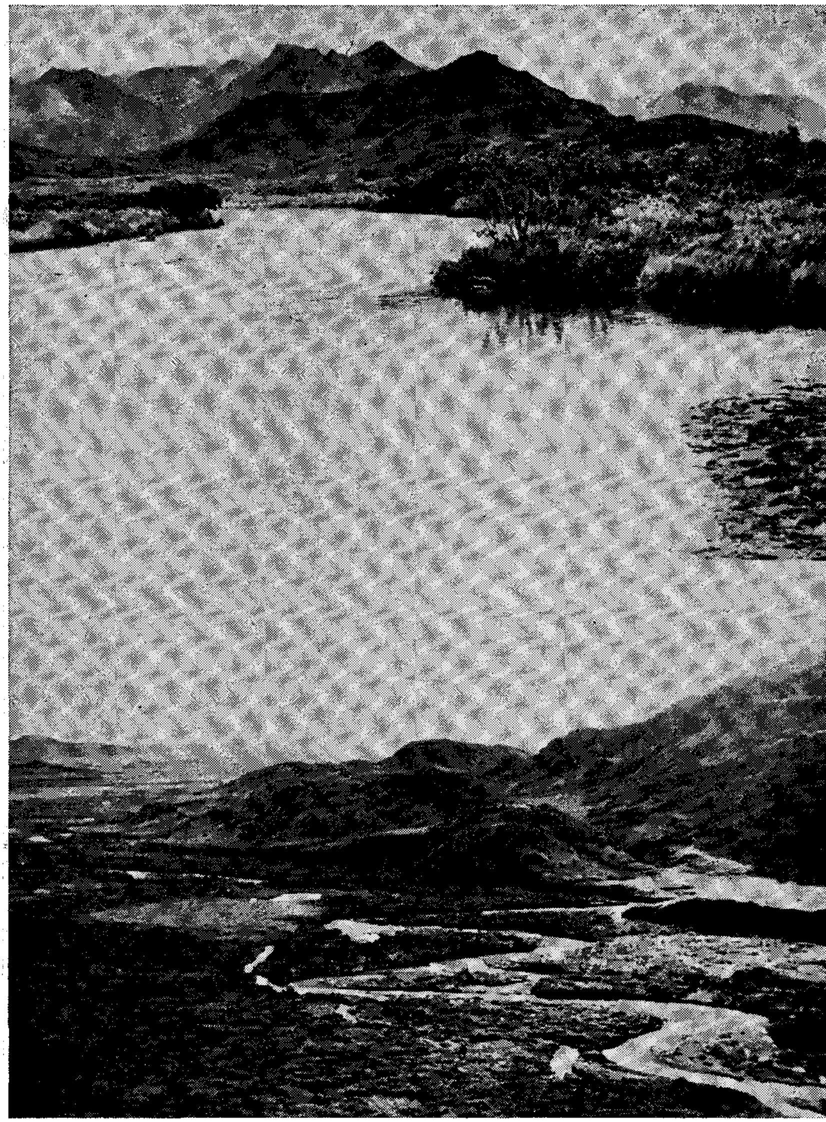


Figure 2. General Physiognomy of the Study Area.

study with the same flight procedures and flight course for each observation period (Figure 1). The pilot was experienced in flying game and fish surveys with several thousand hours of low level game observations. The aircraft was a Piper "150" supercub Model PA-18. This aircraft has a very low (45 mph) stalling speed and permits tandem seating, a feature we consider superior to side-by-side seating as favored by Riordan (op. cit.) and others. This view is held since (except frontally) both the pilot and observer can view things equally. Consequently, the pilot need only maneuver so he can see, to put the observer into proper position for observing and recording. This is particularly difficult with side-by-side seating since the pilot is trying to position the observer on an area he cannot see himself. A further disadvantage of side-by-side seating is that in making circles or "S" turns only the pilot or observer views portions of the area surveyed.

The observers were Department of Fish and Game employees, including the senior author. The observers varied in their working experience with bears: Observer C was without previous experience, observer A had considerable experience observing bears from the ground and observer B had extensive experience observing bears from both the ground and from the air.

Flight periods began precisely at 5:00 a.m., 11:00 a.m., and 5:00 p.m. A.S.T., and each survey continued until completion of the flight course approximately 2½ hours later. For the most part, course legs were flown upstream against prevailing air flows into the drainage basin (Figure 1). This procedure permitted slower ground speeds. Air speeds with flaps extended approximated 60-70 mph. Flight altitude was maintained insofar as possible at 200 feet above the ground.

Bears were tallied on the first passage over the flight course only. That is, bears seen during reflight over portions of the flight course were not counted even if known to have escaped notice. Flight procedures consisted of flying each transect leg in a manner thought most productive for observing bears. Whenever possible this consisted of a series of shallow "S" turns pivoting upon the stream being surveyed. This procedure permitted both the observer and pilot to view all portions of the transect course. All bears sighted by either the pilot or observer were tallied and close circling passes were made to permit their classification as sows with cubs, sows with yearlings or "other bears." The latter were further classified as small, medium, and large. To reduce bias the pilot did not participate in population element classification. The location of each observation was also plotted by composition symbol.

The project design specified that all three surveys for a given day had to be completed to qualify that day in a survey square. Weather caused incomplete surveys to be flown on August 1, 2 and August 15. It was not possible to fly surveys on or between August 8 and August 12. Completion of the survey design was as shown in Table 1.

In addition to testing for differences between observers, dates and times of day, observations were recorded to investigate certain weather factors and bear movements. Weather data were taken at camp quarters at the outlet of Chignik Lake and an estimate of wind velocity was recorded by the pilot when passing over Black Lake at approximately the mid-period of each survey.

Ten simultaneous air and ground counts were made within prescribed areas to ascertain the efficiency of air surveys. The procedure for these was to have a ground observer go to a lookout site one hour in advance of the aerial survey crew and with the aid of binoculars locate bears within test areas and plot their movements. The air crews, similarly, plotted the locations of bears observed, and executed a sharp dip and ascent over them to alert the ground observer of the sightings.

Table 1. Survey Design

Hours	Square 1			Square 2			Square 3		
	July 31	August 3	August 4	August 5	August 6	August 7	August 13	August 14	August 16
0500-0800	A	B	C	B	C	A	C	A	B
1100-1400	B	C	A	C	A	B	A	B	C
1700-2000	C	A	B	A	B	C	B	C	A

A, B, and C are observer designations.

Prior to the execution of the test surveys several steps were taken to standardize procedures. For the period July 23-26 the observers were together at McNeil River on the Alaska Peninsula to observe at close hand the concentrations of bears that gather there and to standardize criteria for classifying identifiable population elements. On July 18, 21, 22, 26 and 28 preliminary evening surveys were flown of the Black-Chignik Lakes drainage to measure fish and bear abundance and distribution and to establish the survey flight course and procedures. A survey was also flown on August 19, three days following completion of the test surveys, to measure the abundance and distribution of bears at that time.

RESULTS

Counts of Bears as Affected by Observer Differences, Days and Hourly Influences

Analysis of the primary design by standard analysis of variance is shown in Table 2 (Steel and Torrie, 1960). This is an examination of the total bears counted during each observation period and is designed to investigate the relation of the observed population to observers, dates, and times of day. A shown in Table 2, this analysis

Table 2. Standard Analysis of Variance of Total Counts

	Square 1				Square 2				Square 3			
Hours	1	2	3	Total	1	2	3	Total	1	2	3	Total
0500	94A	81B	62C	237	81B	65C	86A	232	54C	54A	61B	169
1100	67B	16C	40A	123	43C	44A	48B	135	29A	30B	18C	77
1700	118C	34A	91B	243	95A	113B	70C	278	76B	72C	76A	224
Total	279	131	193	603	219	222	204	645	159	156	155	470

A, B, and C, are observer designations.

Source	d. f.	s. s.	m. s.	F
Squares	2	1854	927.0	4.50*
Days within squares	6	3748	624.7	3.03
Hours within squares	6	10279	1713.2	8.32**
Observers	2	1010	505.0	2.45
Error	10	2059	205.9	
Total	26	18950		

**significant at 1% level
* significant at 5% level

indicates that large differences exist (.01 probability level) in the number of bears observable during different times of the day. Peak activity occurred during the evening observation period and fewest bears were available during the mid-day period. Differences in total bears counted between observers were not significant at the .05 probability level. The bear population diminished slightly toward the close of the study as shown by differences (.05 probability level) in square totals. However, no differences were evidenced between days within individual squares.

This analysis is subject to the necessary assumptions of analysis of variance testing, i. e., the observations are assumed to be normally distributed and the effects additive. Also, the design does not measure interaction. Hence, it is necessary to assume that no interaction exists between these variables.

Compositional Considerations as Related to Observers

During this survey bears were classified into the following categories: 1) sows with cubs, 2) sows with yearlings, 3) cubs, 4) yearlings or 5) "other bears." The other bear category simply included individuals not included in the other four categories. Although obvious differences in size usually permitted ready classification of family groups as being cub or yearling groups, there existed some gradation from very small cubs to large yearlings. The overlap between large cubs and small yearlings was hypothesized to cause subjective classification and thus these individuals may have been classified differently by the observers.

The chi-square test of independence was used to investigate whether classification was consistent from observer to observer. Table 3 indicates, at the .01 probability level, that classification was not independent of observer. The percentages of cubs and sows with cubs recorded by the three observers were directly related to the observers' previous experience in working with bears: the greatest percentages of these components were recorded by the observer most experienced and the lowest percentages by the observer least experienced. Although there was no manner of testing the classification accuracy of individual observers against known population elements, the population composition recorded by observer C seems inconsistent with a natural population structure, *i.e.,* a larger percentage of yearlings than of cubs is not normal considering expected mortality from cubs to yearlings. This perhaps indicates that compositional classification is more accurate when the observers are experienced.

The relation of time period to classification was also investigated

Table 3. Chi-square Test of Independence Between Observer Classifications

Observer	Sows with cubs		Sows with yearlings		Cubs		Yearlings		Other bear		Total
	obs.	exp.	obs.	exp.	obs.	exp.	obs.	exp.	obs.	exp.	
A	80	76.1	66	64.9	161	164.5	129	120.8	116	125.6	552
B	105	89.4	52	76.2	232	193.1	98	141.8	161	147.5	648
C	52	71.5	84	60.9	119	154.4	149	113.4	114	117.9	518
Total	237		202		512		376		391		1718

Total Chi-square = 68.1
significant at 1% level

Percentage occurring in each class

Observer A	14.5	12.0	29.1	23.4	21.0
Observer B	16.2	8.1	35.8	15.1	24.8
Observer C	10.0	16.2	23.0	28.8	22.0

using chi-square tests of independence. The hypothesis being tested is whether classification was independent of time of day. The hypothesis of independence was not rejected (.5 probability level) indicating that the time period a survey was flown had no influence on classification.

The consistency of classification from square to square, for each observer, was checked by chi-square analysis to determine if classification was independent of square influence. This analysis showed that for observers B and C the hypothesis of independence was not rejected at the .05 probability level, indicating that for these two observers, classification was fairly constant throughout the entire survey. Classification was not independent of square influence (.05 probability level) for observer A. As the survey progressed, this individual's data were found to show an increased percentage of cubs and a corresponding decreased percentage of yearlings. The authors feel that the consistency of observers B and C indicates that the population remained fairly constant and that the differences found for observer A are a reflection of his increasing experience and a changing of his classification habits.

In the following section on wind considerations, it will be shown that wind velocity has complicated the interpretation of differences in classification due to observer ability.

The Effect of Wind and other Weather Factors

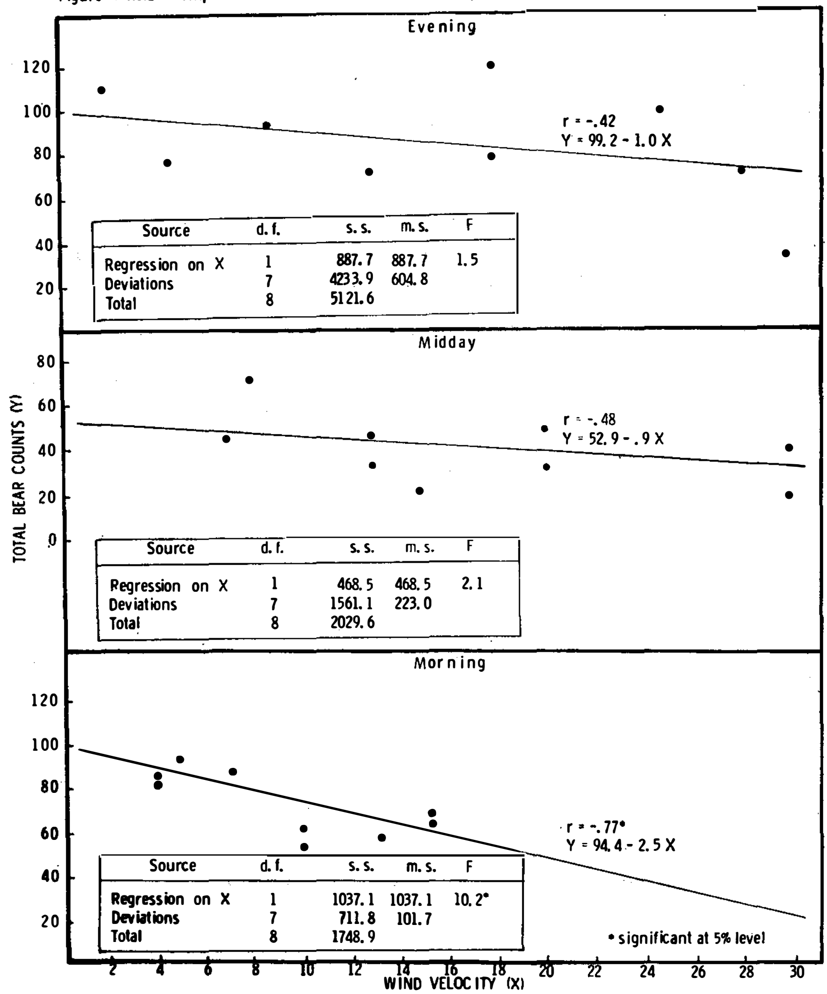
As stated previously, the wind velocity over Black Lake was estimated by the pilot during each observation period. At this location the wind condition was somewhat typical of the flight path as a whole; however, great differences in the wind velocity were often encountered on the survey route due to differences in terrain. These differences in wind velocity over the flight path, and the estimated nature of the measured wind over Black Lake have no doubt caused some additional variation to be included in these data.

As has been shown, differences in bear numbers did occur between time periods. Evidently this was caused by the animals' activity patterns. It was observed also that wind velocity seemed to adversely affect the number of bears seen during an observation period. To investigate this possibility the number of bears counted during each observation period was plotted against wind velocity (Figure 3). These data were grouped by time periods because of the known differences in bear numbers between time periods (Table 2).

Correlation coefficients were computed between wind velocity and bear numbers for each time period to measure the degree of association (Figure 3). Although a negative correlation between the number of bears observed and wind velocity was shown for all time periods, only in the morning period was the correlation (.05 probability level) significant. Even so, however, the correspondence in direction for all periods, considering the variable nature of small-sample correlation coefficients, indicates that bear counts were adversely affected by increasing wind velocities.

The relation of wind velocity to bear numbers was also assumed to be linear and a linear regression equation was computed for each time period (Figure 3). Again, only the morning observation period showed a significant regression at the.05 probability level. The total unadjusted sum of squares for the Y variable (total bear counts) can be partitioned into variance due to regression and deviations from regression. The variance due to regression is a measure of the variation which is contributed because of the relation of wind velocity to total bear counts. The deviations from the regression

Figure 3. Relationship of Total Bear Counts and Wind Velocity For Each Time Period



Evening

Source	d. f.	s. s.	m. s.	F
Regression on X	1	887.7	887.7	1.5
Deviations	7	4233.9	604.8	
Total	8	5121.6		

Midday

Source	d. f.	s. s.	m. s.	F
Regression on X	1	468.5	468.5	2.1
Deviations	7	1561.1	223.0	
Total	8	2029.6		

Morning

Source	d. f.	s. s.	m. s.	F
Regression on X	1	1037.1	1037.1	10.2*
Deviations	7	711.8	101.7	
Total	8	1748.9		

sum of squares is a measure of the deviation of actual bear counts from the regression line. The mean square for deviations is of particular interest as this value is somewhat indicative of the relative stability of the various observation periods. That is, this variance demonstrates the uniformity of early morning bear counts and the relatively low winds at this time as contrasted to the erratic wind velocities and less consistent bear counts obtained for the midday and evening periods.

A further consideration of wind effect is its relation to bear classification. That is, did increased wind cause increases or decreases in certain classification categories? To investigate this, the relation of wind velocity and arcsin $\sqrt{\text{percent}}$ for each bear category was investigated by computing correlation coefficients and linear regression equations. A comparison of these statistics is shown in Table 4: only the relation of wind and arcsin $\sqrt{\text{per cent}}$ sows with cubs constitutes a significant correlation and regression at the .05 probability level. However, to fully assess this relationship it is necessary to consider possible effects of observer and/or time period variations.

As discussed in the analysis of compositional factors, chi-square examination indicated that time periods and classifications of bears were independent. Since time period had no effect on classification it follows that the effect of wind, as related to time periods, was also independent of classification.

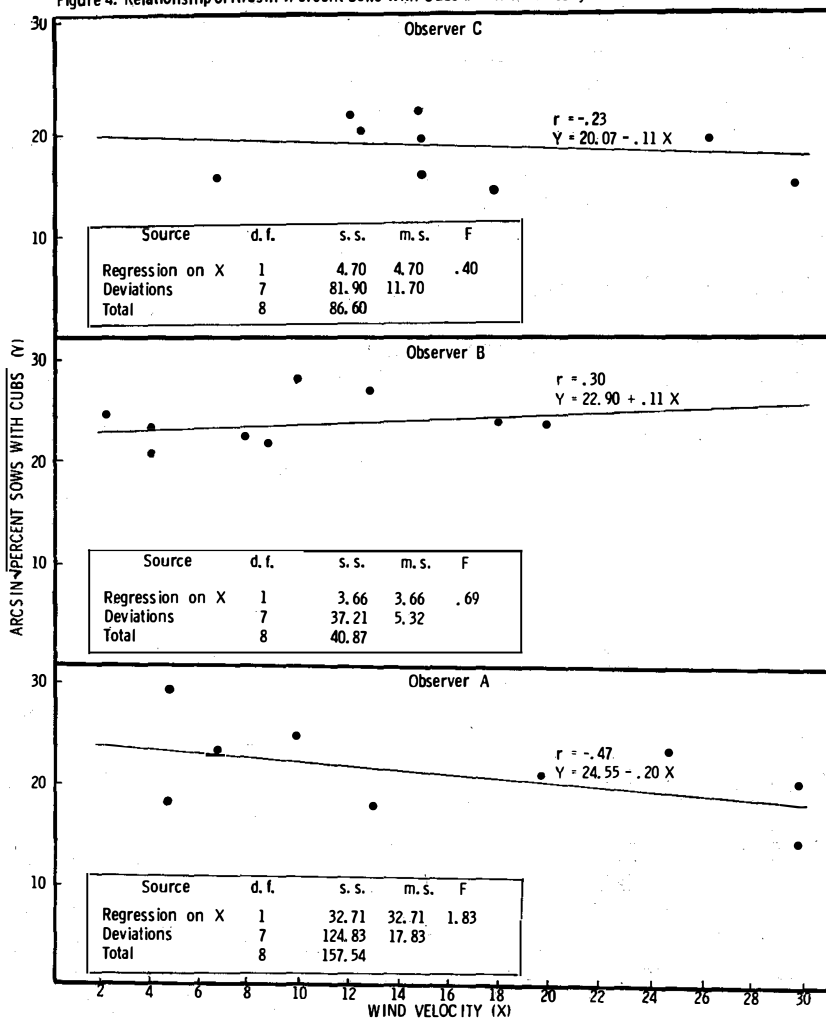
Separation of the effect of wind and observer differences, as related to bear classifications, is more difficult. As shown in the analysis of composition, classification was not independent of observer, i.e., differences existed in the manner in which observers classified bears. Therefore, the wind and arcsin $\sqrt{\text{per cent}}$ sows with cubs relationship was separated by observer to determine if wind velocity influenced all observers equally. Examination of Figure 4 shows that when the data are so separated, none of the relationships constitute a significant (.05 probability level) correlation or regression, and both negative and positive regressions and correlations exist. Therefore, any effect of wind velocity on classification is doubtful. It seems

Table 4. Correlation and Regression Coefficients Examining Wind and Classification Relationships

	Correlation coefficient	Regression coefficient	F ratio
Wind and arcsin $\sqrt{\text{percent yearlings}}$	.24	.17	1.50
Wind and arcsin $\sqrt{\text{percent sows with yearlings}}$	.25	.13	1.64
Wind and arcsin $\sqrt{\text{percent cubs}}$	-.34	-.28	3.36
Wind and arcsin $\sqrt{\text{percent sows with cubs}}$	-.40*	-.19	4.61*
Wind and arcsin $\sqrt{\text{percent other bear}}$	.32	.23	2.81

*significant at 5% level

Figure 4. Relationship of Arcsin $\sqrt{\text{Percent Sows With Cubs}}$ and Wind Velocity For Each Observer



Observer C

Source	d.f.	s.s.	m.s.	F
Regression on X	1	4.70	4.70	.40
Deviations	7	81.90	11.70	
Total	8	86.60		

Observer B

Source	d.f.	s.s.	m.s.	F
Regression on X	1	3.66	3.66	.69
Deviations	7	37.21	5.32	
Total	8	40.87		

Observer A

Source	d.f.	s.s.	m.s.	F
Regression on X	1	32.71	32.71	1.83
Deviations	7	124.83	17.83	
Total	8	157.54		

probable that the significant negative correlation between wind velocity and arcsin $\sqrt{\text{per cent sows with cubs for all}}$ of the data is simply a manifestation of observer differences. That is, examination of Figure 4 shows substantial differences between observer classifications in the average per cent sows with cub category. When these differences are pooled they evidently cause the significant negative correlation previously observed.

Comparisons were also made between the number and classifications of bears observed under varying cloud, temperature and light conditions. These measurements were recorded at field headquarters. Cloud comparisons were based on the percentage of cloud cover. All measurements were taken at approximately the mid-point of the flight periods. None of these factors indicated consistent effects which would have bearing on either the number or the population makeup of bears observed.

Comparison Between Air and Ground Counts

On ten occasions observers were stationed at vantage points on areas overlooking a portion of the regular flight path. The areas to be simultaneously counted from the air and ground were specifically defined prior to the flights. The results of these flights are summarized in Table 5. The "total known bears" consists of bears which were distinguished, and are not necessarily the actual number of bears present in the simultaneous count areas. Obviously great differences exist between the number of bears sighted from the air and from the ground. The area of Upper West Fork is the only location where air counts exceeded ground counts. Considering the averages for all counts, air observers counted about 47 per cent of the known bears in the sample areas. However, it should be noted that the air counts varied from 0 to 88 per cent of the known bears.

The number of bears observed on individual flights was highly variable and, as would be expected, the mean number of bears observed by air crews was in direct relation to cover density (Table 5). Surprisingly though, greatest variations in these limited counts were for areas with sparse cover.

In addition to the preceding evidence, additional data were obtained further demonstrating the incompleteness of these aerial counts. The variations between individual counts are themselves suggestive of this. Perhaps more revealing, however, is the infrequency with which bears of individual character were observed. Three of these will serve to illustrate: a sow with four cubs, a sow with four yearlings and a lone three-legged bear. During the 27 survey flights the cubs were sighted 7 times, the yearlings once, and the lone bear twice. Furthermore, all were sighted in the same general location each time. While it is possible that the crippled bear may not always have been identified, and that the yearling observation may have been a misclassification of the cub litter, it is likewise possible that there may have been more than one four-cub litter in which case each group would have been observed less than the seven times indicated. While neither premise can be verified, it

Table 5. Comparisons Between Simultaneous Air and Ground Counts

Time	Date	Area	Ground Density	Ground count	Air count	Unobserved from ground	Unobserved from air	Total known bear
1713	August 9	Broad-Conglomerate	Moderate	26	11	1	15	27
1700	August 10	Broad-Conglomerate	Moderate	20	7	1	13	21
1915	August 16	Boulevard	Heavy	20	6	0	14	20
1935	August 16	Broad-Conglomerate	Moderate	4	3	3	4	7
0630	August 17	Boulevard	Heavy	6	5	3	4	9
0650	August 17	Broad-Conglomerate	Moderate	13	11	0	2	13
1835	August 17	West Fork	Light	9	14	7	2	16
1842	August 17	West Fork	Light	14	5	1	9	15
0640	August 18	West Fork	Light	5	7.	5	3	10
0649	August 18	West Fork	Light	9	0	0	9	9
Totals				126	69	21	75	147

Cover class	Air count	Total known	Percent observed
Light	26	50	52%
Moderate	32	68	47%
Moderate - Heavy	11	29	38%

seems reasonable to assume that these records indicate that only a small proportion of the bears within the stream system were recorded on individual flights.

OBSERVATIONS OF BEAR MOVEMENTS WITHIN THE STUDY AREA

Table 6 shows the total number of bears that were observed on each system each day. The purpose of this examination was merely to investigate what intermixing, if any, occurred between streams during the study period. Presumably some of the fluctuations in counts of bears during the study may have been caused by wanderings of bears between streams. Table 6 indicates that this factor is probably a minor consideration and that unilateral population exchange was slight. Within a few exceptions, the fluctuations of the bear numbers on each stream would seem to be caused by factors other than population movement between streams. The first observations on Fan and West Fork creeks are certainly large as compared to other observations on these creeks. However, there is little indication that these animals shifted directly to any of the other survey streams, so they perhaps moved to areas not on the flight path. The observations for the rest of the streams generally fluctuate together, although certain streams do suggest peak activity.

Table 6. Daily Bear Counts For Individual Streams

	July	August								
	31	3	4	5	6	7	13	14	16	Total
Fish Creek	7	4	12	10	1	1	2	1	4	42
Chiaktuak Creek	32	25	31	37	38	18	28	39	35	283
Fan Creek	53	5	7	6	10	6	7	10	9	113
Boulevard Creek	35	18	36	30	33	32	25	16	21	246
Alec River	5	2	12	9	6	19	2	14	13	82
Conglomerate Creek	11	19	17	9	13	15	11	9	5	109
Broad Creek	18	11	10	18	23	28	20	16	5	149
Slim Creek	11	11	12	30	34	35	16	4	2	155
West Fork	88	26	41	52	46	35	39	36	49	412
Cathedral Creek	0	1	0	0	0	0	0	0	0	1
Milk Creek	1	7	7	6	9	10	3	3	0	46
Bear Skin Creek	18	2	8	12	9	5	6	8	2	70
Unnamed Creek	0	0	0	0	0	0	0	0	10	10
Total	279	131	193	219	222	204	159	156	155	1718

DISCUSSION

This study serves to demonstrate some of the influences which must be considered when using aerial observations for population analysis of brown bears. The findings do not negate the use of aerial surveys but show that with attention to standardization of controllable variables and with awareness of the limitations in the use of aircraft, aerial observations provide perhaps the only feasible means for extensive population assessments. Also, the findings of this study suggest that similar influences may have bearing on the results of aerial surveys of other game species.

Observations of Bear Movements Within the Study Area

It has been shown that the number of bears available during morning, mid-day and evening periods varied greatly. While the average number of bears counted during any one time period is obviously not an enumeration of all bears present, the question does arise as to when and how many flights should be made to make the data comparable on a yearly and area basis. Using the estimated variance of the mean for each time period, it is possible to compute the approximate number of replicate flights needed to estimate the true time period means within 10 per cent, with only a

5 per cent chance of being wrong (Cockran, 1953). These computations indicate that it would take 15 morning, 65 mid-day and 33 evening flights to meet these requirements. While such large samples are not encouraging, this analysis does indicate when flights should be made, and what sample sizes are necessary to detect changes in levels of abundance between areas and years.

Daily bear counts during the study period were shown to be relatively consistent, with preliminary and post surveys indicating that sizable bear numbers were available from at least July 10 to August 19. The existence of bear concentrations is assumed to be dependent on salmon availability. Because of the great differences in the timing of salmon migrations on the Alaska Peninsula, periods of bear concentrations are variable between systems. Therefore, prior knowledge of bear and salmon relationships is necessary before initiating surveys of this nature.

Despite the fact that the observers differed both in their experience with bears and in aerial counting, no differences in their ability to count total bears (with the same pilot) were detected. Although not tested in the study, the authors feel that as long as the pilot has extensive experience in low level game and fish surveys, his ability to sight bears probably has a minor influence on survey results.

Observers did not classify bears similarly into identifiable population components and it appears that the major discrepancies in classification resulted between cub and yearling litters. Therefore, it appears that beyond simple classification of bears as family groups and "other bears," compositional classifications between observers cannot be considered accurate. This study and work by Bevan (op. cit.) indicates that, wherever judgment considerations are concerned, results of estimates or classifications by several observers cannot be considered reliable. For these reasons, aerial surveys intended for comparisons of population structure or of estimated population size between areas or years should, insofar as possible, be made by one observer. Even here, however, compositional findings for an individual observer should be considered of only relative value unless some means can be devised for testing classification accuracy.

Certain weather conditions also affected survey results. Temperature, light intensity and cloud cover gave no evidence of influencing counts; wind velocity apparently influenced the number of bears observed, but not compositional status. It is uncertain whether the wind influenced the bears, the aerial survey procedures, or both. There is little question that wind had at least some effect on survey procedures. Increased winds and air turbulence are closely associated. Flight configuration and maneuvers under such conditions were of necessity different than under low wind and non-turbulent conditions. The air speed factor alone may have been of considerable importance. Turbulence did not affect survey coverage but may have affected the survey crews' comfort and state of mind, although none of the observers experienced air sickness.

As has been reported by Sumner (op. cit.), Edwards (op. cit.) and Watson and Scott (1956), air counts were low compared to ground counts. Our simultaneous air and ground counts were made under conditions fairly typical for the Alaska Peninsula; approximately half of the bears known to be present in survey areas were observed from the air. These observations and other considerations indicate that fewer bears were seen on these surveys than were actually present in the study area.

SUMMARY

A statistical evaluation of a number of variables affecting aerial surveys on brown bears was carried out in the Chignik-Black Lakes area of the Alaska Peninsula, Alaska. The primary design consisted of three replicates of a 3-by-3 Latin square testing for differences between observers, dates and times of day. Analysis of variance tests showed that real differences (.01 probability level) existed in total bear counts between hourly periods within days. Peak activity occurred during the evening sampling period (5 to 7:30 p.m.) with least activity occurring at mid-day (11 a.m. to 1:30 p.m.). Differences in total bear counts between observers and between days within squares were not statistically significant at the .05 probability level. However, differences, at the .05 probability level, were found between replicate squares. Wind velocity was found to adversely affect the numbers of bears counted during observation periods with lowest counts associated with increased wind velocities.

Chi-square examinations for independence of compositional classification and observer abilities, times of day and dates were considered. Observers did not consistently classify bears in the same categories (.05 probability level). However, classification was independent of time period or date influence at this probability level. The proportion of cub groups, yearling groups and "other bears" counted was not influenced by wind velocity.

Total counts for the morning surveys were less variable than for other time periods. Therefore, if survey results are to be used for comparisons between areas or years, this time period would give most uniform comparisons. Also, if classification comparisons are to be meaningful they should be restricted to individual observers whose classification habits are consistent.

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RESIDUES IN GAME ANIMALS RESULTING FROM FOREST AND RANGE INSECTICIDE APPLICATIONS

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In discussing pesticide-wildlife problems Leedy (1959) commented that game administrators would be particularly interested in the effects of forest insect control on populations of deer and elk, as well as on fish and valuable fur animals. Since most of the big game hunting in the western United States takes place on forest or range lands, the extensive forest areas sprayed for control of pests such as spruce budworm or rangelands sprayed for control of grasshoppers are viewed by sportsmen and others interested in wildlife with increasing interest.

Aerial spraying of forests for insect control has generally been with DDT applied at a rate of 1 pound per acre; but one-half and even one-quarter pound per acre applications of DDT have been used to reduce hazard to wildlife, especially along fishing streams and around lakes. No significant effects on bird or mammal populations have been apparent to date from such applications. However, Wright (1960) has noted reduction in woodcock reproductive success

[1]Research biologists.

in forested areas treated with DDT as compared to untreated areas in New Brunswick. As a means of learning something about the exposure and possible indirect or long-term effects of such programs on wildlife, tissue samples from mule deer and elk have been analyzed for residues of or derived from DDT.[1] Some tissue residues also have been determined from two captive mule deer given an artificial diet containing a known amount of purified DDT.

Aerial spraying of rangelands for grasshopper control has generally been with aldrin at 2 ounces per acre or dieldrin at one-half to 2 ounces per acre. These materials are many times more toxic than DDT, but field observers have not seen noticeable effects on bird and mammal populations when these application rates are used on dry rangelands. Since aldrin is known to be converted to dieldrin in animal tissue (Bann *et al.* 1956), tissue samples collected from areas sprayed with aldrin have been analyzed for dieldrin as well as aldrin.

Residues in wildlife resulting from field applications of dieldrin or heptachlor in the southeastern United States have been reported by DeWitt *et al.* (1960) and by Rosene *et al.* (1962).

METHODS AND MATERIALS

Samples of big game tissues when collected in the field are placed in separate polyethylene bags and labeled. These are then frozen and shipped to the Denver Wildlife Research Center where they are stored in a freezer pending analysis. To prepare a tissue for analysis, it is thawed and the desired portion (usually 5 grams for fat and up to 25 grams for other tissues) is weighed and ground with sufficient anhydrous sodium sulfate to dehydrate the sample. The thawed or fresh "wet" weight of tissue is used as the basis for computing the parts per million (p.p.m.) of chemical residue found.

Although samples of fat and muscle tissue are easily obtained from hunter check stations and by contacting hunters in the field, most other tissues must be collected by trained personnel participating in the study. This necessarily limits the number of samples of vital organs that can be obtained.

Analysis of the residue content of the prepared sample was performed in the following steps: (1) extraction of the pesticide from the sample with petroleum ether in a Soxhlet extractor, (2) clean-up of the extract by liquid-liquid partition with acetonitrile and n-hexane, (3a) additional clean-up by sulfonation of the residue

[1]DDT and derived residues reported in this paper are as follows:
DDT: 1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane
DDE: 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene
DDD: 1-1-dichloro-2,2-bis(*p*-chlorophenyl)ethane
DDMU: 1-chloro-2,2-bis(*p*-chlorophenyl)ethylene

with fuming sulfuric acid, or (3b) additional clean-up by passage through a column containing magnesium oxide and celite, (4) paper chromatographic separation and identification of the pesticides present by the methods of Mitchell (1958) using a solvent system of 2-phenoxyethanol with 2,2,4-trimethylpentane.

Identification and approximate amounts of pesticides present are determined by visual comparison of spots produced on the paper chromatogram by the sample extract and by known amounts of reference materials. Step 3a is used to distinguish the several metabolites of DDT, but if dieldrin is suspected step 3b is used to avoid destruction of dieldrin by sulfuric acid.

RESULTS

It is essential to the appraisal of field effects of pesticides on wildlife for studies to be conducted concurrently with the extensive control operations (Leedy 1959), so that the effects can be evaluated and methods found for keeping wildlife losses to a minimum. Most of the residue studies reported here were made in conjunction with several control operations.

Spruce Budworm Control Operations: The Bitterroot area, about 74,000 acres on the East Fork of the Bitterroot River in the Bitterroot National Forest in Montana, was sprayed aerially with DDT in July 1959. Much of the same area had been sprayed previously with DDT in July 1955 for the control of spruce budworm. Tissue samples were analyzed from six mule deer collected after the spraying by personnel of the Montana Department of Fish and Game and the results are presented in Table 1.

The Gallatin area, about 60,000 acres along the Gallatin River in the Gallatin National Forest, Montana, was sprayed with DDT in July 1960. Tissue samples were analyzed from 10 mule deer collected by the Montana Department of Fish and Game, and the results

TABLE 1. DDT AND DERIVED RESIDUES IN MULE DEER COLLECTED AFTER THE 1959 SPRUCE BUDWORM CONTROL OPERATION, BITTERROOT NATIONAL FOREST, MONTANA

Sample No.	Sex and Age	Kind of Sample	Date Collected	Residues (in p.p.m.)			
				DDE	DDT	DDD	DDMU
4030	Fawn	Fat	Nov. 1959	1	5.0	3	0
		Lean meat		<0.5	<0.5	0	0
4031	Fawn	Fat	Nov. 1959	0	9.0	0	0
4028	Fawn	Lean meat	Nov. 1959	0	1.0	0	0
4029	Buck	Lean meat	Nov. 1959	0	0.8	0	0
4086	Doe	Fat	July 1960	3.0	0	3.0	0
		Lean meat		<0.5	0	1.0	0
		Brain		<0.5	0	<0.5	0
		Liver		0	0	1.0	3.0
		Kidney		0	0	0	25.0
4291	Buck	Fat	Nov. 1960	<0.5	<0.5	<0.5	0
		Lean meat		0	<0.5	<0.5	0

are presented in Table 2. A blue grouse collected about a month after the spraying contained 1.6 ppm of DDE. Unfortunately, no samples were collected from big game animals killed by hunters.

The Pecos area, a portion of over 430,000 acres in the Carson and Santa Fe National Forests, New Mexico, was sprayed with DDT in June 1962. Tissue samples were analyzed from 3 mule deer collected prior to the hunting season, and from 8 deer and 24 bull elk killed by hunters in the 1962 hunting season and collected at the hunter check station in Pecos. The results of residue analyses of 33 samples collected after the spraying are presented in Table 3.

The Rio Grande area, about 86,000 acres mostly on the South Fork drainage of the Rio Grande River in the Rio Grande National Forest, Colorado, was sprayed with DDT in June, 1962. A lactating doe killed 7 weeks after the spraying had in the fat 3.2 p.p.m. of DDE, 32 p.p.m. of DDT, and 2.4 p.p.m. of DDD; the rumen content had 5 p.p.m. of DDE, 1.4 p.p.m. of DDT, and 2 p.p.m. of DDD. Fat samples were analyzed from 10 deer and 7 elk killed in October, 1962 (See Table 4).

Purified p,p' DDT was administered to two captive mature female mule deer. One was fed 15.2 grams of DDT over a period of 67 days, or 258 milligrams per kilogram of body weight. This deer showed no noticeable symptoms of poisoning and was sacrificed for residue determinations. The other deer was given a single dose of 500 milligrams per kilogram in olive oil by intrarumen injection. She died within 48 hours after showing convulsive symptoms and tremors. Since this doe was otherwise in poor condition at the time of the test, the dose given was probably less than would be required

TABLE 2. DDT AND DERIVED RESIDUES IN MULE DEER COLLECTED BEFORE AND AFTER THE 1960 SPRUCE BUDWORM CONTROL OPERATION, GALLATIN NATIONAL FOREST, MONTANA

Sample No.	Sex	Kind of Sample	Date Collected	Residue (in p.p.m.)			
				DDE	DDT	DDD	DDMU
Prespray							
4160	Buck	Tissue composite	June 1960	0	0	0	0
4161	Buck	Tissue composite	June 1960	0	0	0	0
Postspray							
4344	Buck	Fat	Aug. 1960	0	24.0	3.0	0
		Liver		0	<0.5	3.0	0
4323	Buck	Fat	Aug. 1960	0	19.2	4.0	0
		Liver		0	0	4.0	0
4319	Buck	Fat	Sept. 1960	0	19.0	1.9	0
		Liver		0	0	3.2	0
4334	Buck	Fat	Sept. 1960	0	12.0	3.0	0
		Liver		0	0	0.5	0
4528	Buck	Fat	June 1961	0	<0.5	<0.5	0
5033	Doe	Fat	June 1961	0	0	0	<0.5
		Liver				<0.5	0.6
4537	Buck	Fat	July 1961	0	0	<0.5	0
4536	Buck	Fat	July 1961	0	0	0	0

TABLE 3. DDT AND DERIVED RESIDUES IN FAT SAMPLES OBTAINED FROM DEER AND ELK AFTER THE 1962 SPRUCE BUDWORM CONTROL OPERATION, SANTA FE NATIONAL FOREST, NEW MEXICO

Sample No.	Sex	Kind of Sample	Date Collected	Residues (in p.p.m.)			
				DDE	DDT	DDD	DDMU
ELK							
5415	Bull	Visceral fat	Oct. 1962	2.6	3.8	<0.5	0
5416	Bull	Visceral fat	Oct. 1962	2.4	1.7	<0.5	0
5418	Bull	Subcutaneous fat	Oct. 1962	2.4	1.4	<0.5	0
5419	Bull	Subcutaneous fat	Oct. 1962	12	9.6	<0.5	0
5420	Bull	Subcutaneous fat	Oct. 1962	3.4	2.9	<0.5	0
5421	Bull	Subcutaneous fat	Oct. 1962	2.9	4.8	0	0
5422	Bull	Subcutaneous fat	Oct. 1962	6	8.2	<0.5	0
5423	Bull	Subcutaneous fat	Oct. 1962	4.8	4.8	<0.5	0
5424	Bull	Subcutaneous fat	Oct. 1962	4.8	6	0	0
5425	Bull	Subcutaneous fat	Oct. 1962	3.8	4.8	<0.5	0
5426	Bull	Subcutaneous fat	Oct. 1962	2.9	2.7	<0.5	0
5427	Bull	Visceral fat	Oct. 1962	3.2	3.4	<0.5	0
5428	Bull	Visceral fat	Oct. 1962	4.4	4.8	<0.5	0
5429	Bull	Visceral fat	Oct. 1962	3.8	5.3	3.4	0
5430	Bull	Subcutaneous fat	Oct. 1962	<0.5	<0.5	0	0
5431	Bull	Visceral fat	Oct. 1962	3.4	3.8	0	0
5432	Bull	Subcutaneous fat	Oct. 1962	4.8	6	<0.5	0
5433	Bull	Subcutaneous fat	Oct. 1962	<0.5	<0.5	0	0
5434	Bull	Subcutaneous fat	Oct. 1962	<0.5	2.4	0	0
5435	Bull	Subcutaneous fat	Oct. 1962	0	1.9	0	0
5436	Bull	Subcutaneous fat	Oct. 1962	0	1.8	0	0
5437	Bull	Subcutaneous fat	Oct. 1962	0	0	0	0
5438	Bull	Visceral fat	Oct. 1962	<0.5	9.6	0	0
5439	Bull	Subcutaneous fat	Oct. 1962	0	<0.5	0	0
DEER							
5328	Buck	Visceral fat	July 1962	<0.5	4.8	<0.5	0
5440	Deer*	Fat	Nov. 1962	0	6	<0.5	0
5441	Deer*	Fat	Nov. 1962	0	3.4	0	0
5442	Deer*	Fat	Nov. 1962	0	2.4	0	0
5443	Deer*	Fat	Nov. 1962	0	8.2	<0.5	0
5444	Deer*	Fat	Nov. 1962	0	6	0	0
5445	Deer*	Fat	Nov. 1962	0	12	<0.5	0
5446	Buck	Fat	Oct. 1962	0	3	0	0
5447	Buck	Fat	Oct. 1962	0	8.2	<0.5	0

*Sex unknown.

TABLE 4. DDT AND DERIVED RESIDUES IN FAT SAMPLES FROM DEER AND ELK KILLED IN OCTOBER AFTER THE 1962 SPRUCE BUDWORM CONTROL OPERATION, RIO GRANDE NATIONAL FOREST, COLORADO

Sample No.	Sex and Age	Kind of Sample	Residues (in p.p.m.)			
			DDE	DDT	DDD	DDMU
DEER						
5482	Buck	Visceral fat	<0.5	27.5	2.7	0
		Subcutaneous fat	<0.5	36.7	5.5	0
5483	Buck	Visceral fat	0	11	2.7	0
		Subcutaneous fat	0	27.5	2.7	0
5492	Buck	Subcutaneous fat	0	14.7	3.1	0
5485	Buck	Visceral fat	0	6	<0.5	0
5481	Buck	Visceral fat	0	4.4	0	0
5486	Buck	Subcutaneous fat	<0.5	1.5	<0.5	0
5484	Buck	Subcutaneous fat	0	0	0	0
5493	Doe	Visceral fat	0	<0.5	0	0
5497	Doe	Subcutaneous fat	<0.5	<0.5	0	0
5496	Fawn	Subcutaneous fat	<0.5	<0.5	<0.5	0
ELK						
5495	Cow	Visceral fat	5	19	5	0
5489	Cow	Subcutaneous fat	7.2	7.7	2	0
5494	Cow	Visceral fat	4.8	6.8	<0.5	0
5487	Cow	Subcutaneous fat	3.2	5.8	1	0
5491	Bull	Subcutaneous fat	2.4	4.8	<0.5	0
5490	Cow	Visceral fat	<0.5	3.8	<0.5	0
		Subcutaneous fat	<0.5	4.8	<0.5	0
5488	Bull	Subcutaneous fat	<0.5	<0.5	0	0

TABLE 5. DDT AND DERIVED RESIDUES IN MULE DEER EXPERIMENTALLY EXPOSED TO PURE *p.p.'* DDT AT THE DENVER WILDLIFE RESEARCH CENTER

Test Animal	Kind of Sample	Residues (in p.p.m.) DDE	DDT	DDD
5 year doe (chronic test)	Fat	0	50	30
	Lean meat	0	0.5	0.2
	Liver	0	0	2
	Brain	0	<0.5	<0.5
	Adrenals	0	0	4.5
	Heart	0	0.4	0.7
	Ovaries	0	<0.5	8
	Kidney	0	<0.5	<0.5
	Spleen	0	<0.5	<0.5
	Lymph nodes	0	3.6	1.8
	Thymus	0	5.6	4.1
	Pancreas	0	1.3	0.6
Pregnant doe (acute test)	(No fat present)			
	Liver	0	1	38
	Brain	0	16	3.6
	Adrenals	0	11	65
	Kidney	0	7	4
	Placenta	0	2	0.8
	Fetus	0	7	13

to kill a healthy deer. The DDT and derived residue found in tissues from these two test deer are given in Table 5.

Grasshopper Control Operations: Information on dieldrin residues in tissues of game animals is much less than that on DDT and derived residues. It is assumed that the lower rates of application would result in lower residues. More uniform deposits would be expected on less mountainous terrain. However, the effect of drouth, vegetation cover, deposition of body fat and movements of wildlife with respect to sprayed and unsprayed areas would be expected to influence residues, as they do for spruce budworm control operations.

Tissue samples have been analyzed from one mule deer, one white-tailed jackrabbit and five sharp-tailed grouse collected on the Strand Ranch in Choteau County, Montana, about a month after dieldrin was sprayed at one-half ounce per acre on some 3,000 acres of rangeland. The residues of dieldrin found varied from zero to less than two-tenths of a part per million.

Fat samples from two mule deer collected after the 1961 grasshopper control operation in Rosebud County, Montana, where aldrin was applied at two ounces per acre, contained no residues though the Montana Department of Fish and Game personnel who collected the samples considered these deer as residents of the sprayed area. However, the fat samples from an antelope collected in the same area contained three p.p.m. of dieldrin. Mule deer collected about a month after the 1961 grasshopper control operation west of Sheridan, Wyoming, where aldrin was applied at 2 ounces per acre, did contain dieldrin residues. A mature and very fat buck contained 3.3 p.p.m. of dieldrin in the visceral fat and 2.6 p.p.m. of dieldrin in the subcutaneous fat. A lactating doe with little fat present contained 1.2 p.p.m. of dieldrin in its fat. A composite sample consisting of heart, liver, kidney, brain, and lean meat from a white-tailed jackrabbit contained 3 p.p.m. of dieldrin, while an aliquot of an entire sharp-tailed grouse contained 0.6 p.p.m. of dieldrin.

DISCUSSION

From the preceding data it is clear that residues may be expected in tissues of game animals as a result of insect control operations. Considerable variation will be noted in the tabulated data. There are too many unknowns and unmeasured variables associated with these residues to permit adequate interpretation, and consequently the following discussion considers possibilities rather than concrete relationships.

It is well known that residues of DDT and of other chlorinated hydrocarbon insecticides are accumulated and stored in fatty tissue. It has been speculated that the residues stored in fat may become important when fat reserves are rapidly mobilized as a result of illness, starvation, or breeding activity. Dale *et al.* (1962) showed that starvation in the rat resulted in mobilization of body fat, which caused an increase in the DDT and derived materials in the remaining fat and other tissues.

The tabulated data on residues in fat of deer and elk would be of greater value if the total amount of fat on each animal were known. The residues reported for fawns in Table 1 represent no large amount of stored DDT, because fawns in October and November have little body fat present. Mature bucks collected before the spraying in the Gallatin area had very little fat and no detectable DDT residues, while those collected 30 and 60 days after the spraying (Table 2) had large deposits of body fat and appreciable residues of DDT. Mule deer bucks both in captivity and in the wild build up extensive fat reserves during the summer and early fall. The time of rapid deposition of fat varies with sex, locality, and individual. When fat deposition occurs immediately following a spray operation, it seems logical to expect greater absolute amounts of chemical residues to be stored in fat. Since fat is not necessarily deposited or mobilized at the same rate in all parts of the body, differences in residue concentration in different fat reservoirs may be expected, as shown by subcutaneous and visceral fat samples from the same individuals (Table 4).

A comparison of the residues found in elk and deer, particularly as shown in animals from the Pecos and Rio Grande areas (Tables 3 and 4), reveals the usual presence of DDE as well as DDT in elk fat, whereas DDE was rarely present with DDT in deer fat. This seems to be true of both sexes. We can offer no explanation for this observed species difference in response to DDT-spray exposure.

Regardless of residues derived from DDT found in fatty tissue, those in the associated lean meat, as shown in Table 1, have always been less than 2 p.p.m. Residues in other tissues are of interest because of the effects these chemicals might have on organ functions.

Residue concentrations in the liver are usually higher than in other tissues except fat. DDT-derived residues in liver usually consist mostly or entirely of DDD. (See Tables 2 and 5). The conversion or metabolism of DDT to DDD in animal tissues, especially liver, has been investigated at the Denver Wildlife Research Center in experiments involving dosing of other experimental animals with pure *p,p* 'DDT. Results of these tests have been written for publication elsewhere.

The doe on the acute toxicity test exhibited central nervous system symptoms of tremors and convulsions, and had higher residues in brain tissue (Table 5) than were found in any other deer. This observation agrees with those of Dale *et al.* (op. cit.) who reported that high brain residues occurred when such symptoms were observed in white rats exposed to DDT.

Nelson and Woodard (1949) noted that following the administration of technical grade DDD to dogs there was atrophy of the adrenal cortex and some evidence of liver damage. A possible affinity of the adrenals for *p,p* 'DDD is suggested by the large residue of DDD found in the adrenals from the doe on the acute test (Table 5). Because of the importance of the adrenal cortex in adaptation or resistance to stress, such an affinity and resulting action of DDD on the adrenals may represent a mechanism for producing adverse delayed effects on wildlife.

Considerable variation in forage contamination and wildlife exposure to DDT is to be expected from spray patterns resulting from precautions aimed at minimizing effects of spraying on fish, wildlife, and domestic livestock. These precautions include not spraying within a quarter of a mile of a main fishing stream or lake, applying only one-half pound of DDT per acre to buffer strips along streams, and not spraying the larger meadows, brush, and aspen stands within the spray block boundaries. Additional variation in forage contamination is attributed to mountainous terrain and weather, which cause irregular flight patterns and drift of spray clouds.

The actual deposit reaching the ground may be estimated from cards coated with an oil-sensitive dye which are exposed during the spraying. A deposit on the ground of about 0.20 pounds per acre is needed to get desired control of spruce budworm. Gorham (1961) reported some spray card data from Maine where 1 pound per acre was applied. On four 10-station lines his estimated deposits ranged from 0.01 to 1.2 pounds per acre.

To obtain some information on forage contamination in the Gallatin area 13 vegetation samples were clipped adjacent to exposed spray-deposit cards. The sample associated with the heaviest apparent deposit on a card contained 245 ppm of DDT on the basis of air-dried sample weight, while chemical analysis of the card gave an equivalent of 0.26 pounds per acre deposit. The other 12 vegetation samples were composited into a single air-dried sample that contained 205 ppm. The average rate of deposition estimated from the spray-deposit cards was about 0.2 pound per acre.

From the above information it would appear that for stations with spray cards showing an actual deposit rate of 1 pound per acre, residues on forage might be as high as 1,000 ppm on a dry-weight basis. Spray deposit on forage would be lessened if intercepted by trees; furthermore, the character of the ground cover would also affect the degree of forage contamination, as a sparse cover would allow spray to fall directly on soil while a tall dense cover would have a diluting effect. Stage of vegetative growth would also affect forage contamination.

Drouth prevailed prior to and during the 1962 spraying in New Mexico, and deer and elk were moving to the moister meadows and valley bottoms to feed. Within a month after the spraying, rainfall had stimulated new uncontaminated growth of forage on the upper slopes. As a result, feeding deer were utilizing this new growth. Lack of such drouth preceding and during the 1962 spraying in Colorado resulted in earlier production of new growth of forage that became contaminated at the time of spraying. This may account for the higher maximum residues found in the deer from the Rio Grande area (Table 4).

In addition to the above variables, the unrestricted movements of the animals sampled also contribute to the variations of residues found in the deer and elk samples. The distribution of the samples collected from deer and elk killed in the Pecos River drainage, New Mexico, is shown in Figure 1. Only the last two digits of the sample number are used to relate the location on the map to the residues presented in Table 3. Four of nine elk killed outside the general spray boundary had less than 0.5 ppm of DDT and derived residues. The remaining five had larger residues best explained by move-

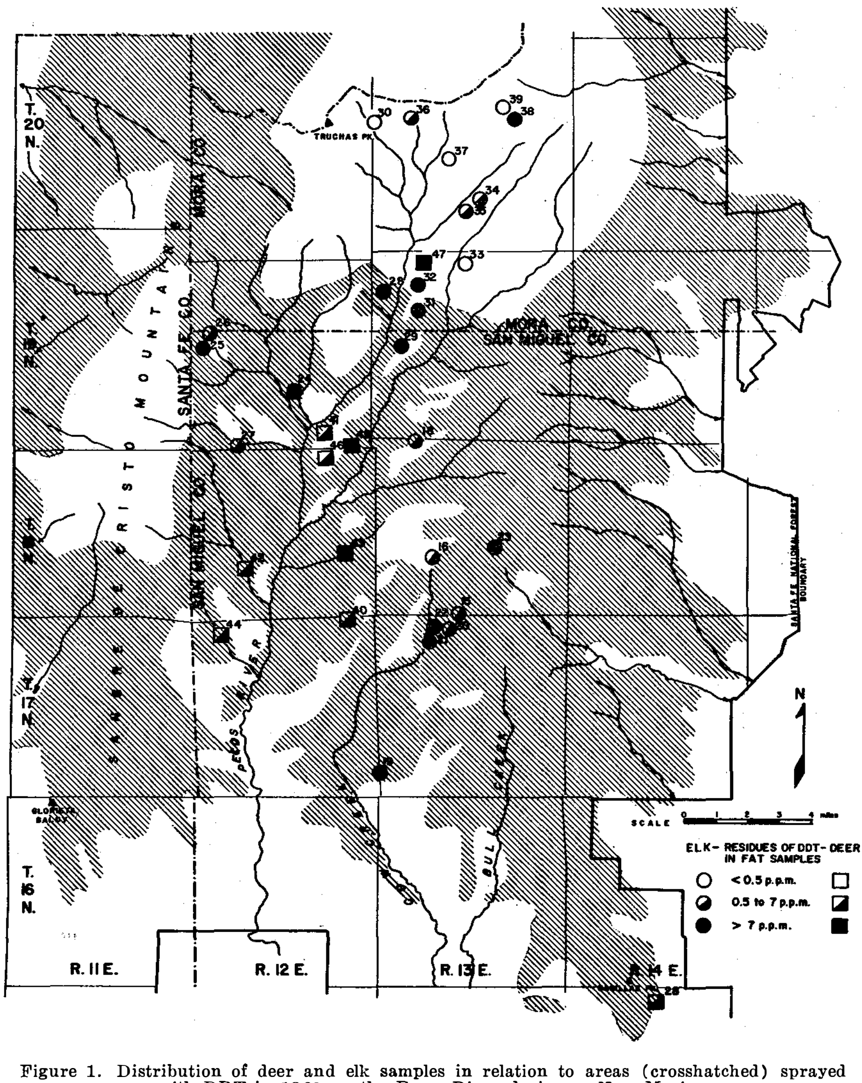

Figure 1. Distribution of deer and elk samples in relation to areas (crosshatched) sprayed with DDT in 1962 on the Pecos River drainage, New Mexico.

ment of the elk out of the sprayed area. Variation in residues within the sprayed area probably represents variation in spray deposition and movements of animals with respect to unsprayed, lightly sprayed, or normally sprayed (1 pound per acre) areas.

Similarly in the Rio Grande area, variation in residues can be accounted for by location with respect to sprayed and unsprayed areas, as illustrated by absence of residue in deer No. 5484 (Table 4) collected outside the sprayed area; whereas deer collected within the general spray boundary but associated more with unsprayed or lightly sprayed areas had low residues (Nos. 5485, 5481, 5486, 5493, 5497, and 5496). Deer collected more within sprayed areas had higher residues (Nos. 5482, 5483, and 5492). Elk, as to be expected from their more extensive movements, show residues not so closely related to spayed areas, as illustrated by No. 5491 which was farther out of the sprayed area than deer No. 5484 but contained residues. However, the elk killed farthest from the sprayed area (No. 5488) contained only trace amounts of insecticide residues.

In the 1960 hunting season on the Rio Grande area, pre-spray samples were obtained from three deer and two elk. Trace amounts of DDT-derived residues were found in all three deer and one elk. The fat sample from the remaining elk, a young bull, was found to contain 24 ppm of DDT, a trace of DDD, but no DDE. No source of DDT to explain this residue is known to us, but elk do sometimes feed in the valley bottom where they might pick up DDT from irrigated fields or the vicinity of resorts.

In Tables 1 and 2 are reported analyses of six deer killed about a year or more after the DDT spraying in Montana. Only one of these showed residues in more than trace amounts. However, this was a mature lactating doe, and of the six represents the one most likely, from knowledge of deer behavior, to have been resident within the sprayed area during and after the application. No actual DDT was present in tissue samples, but its metabolites, DDE, DDD, and DDMU were present. It is noteworthy that the only other deer in which DDMU was found (No. 5033, Table 2) was also taken a year after spraying.

The presence of residues of DDT in game animals raises the question of what harmful effects, if any, may come to the game animals from such exposure and residue accumulation. This cannot yet be answered. Although no immediate gross effects have been observed in deer, there may be long-term indirect effects on their health or reproductive success. For instance, a buck feeding on treated range for several weeks in late summer while laying on fat may store up such an amount of pesticide residues as could affect its health when this fat is metabolized during rut and the ensuing period of winter stress and malnutrition. Or the mobilization of fat and stored pesticide residues may affect fertility, development of embryos, or vitality and survival of fawns.

The question of whether insecticide residues found in game animals may be injurious to people consuming the game has often been asked. No regulations have been specifically adopted relating to harvest of game animals containing residues. The U. S. Food and Drug Administration has established tolerance limits for pesticide residues in food in interstate commerce. Such a "tolerance" is a permissible limit of a chemical residue that may not be legally exceeded. The tolerance for DDT in domestic livestock is 7 ppm in the fat. There is no tolerance for dieldrin in livestock, hence no residue is permissible. Although the amount of residues found in game animals sometimes exceeds these tolerances, only federal and state health agencies can answer whether these tolerances should be applied to game.

All agencies assisting in this study have expressed the need for more information on residues in game animals, in order to have a better basis for management decisions affecting game and hunters. Further studies should lead to better knowledge of the rates of residue accumulation, maximum amounts to be expected under known conditions, rates of residue elimination, and the timing of these changes with respect to hunting seasons and periods of extreme physiological demand on the game animals. To attain this we need studies providing better knowledge of forage contamination. Attempting to achieve this in connection with extensive pest control operations is often not possible, because changes must often be made in control plans and operations too late for us to adjust to them. Research studies in sprayed enclosures, set up independently of pest control operations, would seem to be the most practical approach for further work.

SUMMARY

1. Sampling of tissues of game animals from forests treated with DDT for control of spruce budworm revealed the presence of DDT and derived residues in the fat ranging from 0 to 42 parts per million. Other tissues contained lesser amounts of residues.

2. Lower residues of dieldrin (from 0 to 3.3 ppm) were found in some fat samples of game animals from rangelands treated with aldrin or dieldrin for grasshopper control.

3. Wide variations in concentrations and total amounts of residue in deer and elk are caused by many factors, including spray area patterns, condition of vegetation, movements and behavior of game species, and physiological condition of the animal.

4. The significance of these residues and their rates of elimination are not yet known.

ACKNOWLEDGMENTS

We are grateful to personnel of the state game and fish departments of Montana, Wyoming, Colorado and New Mexico for their assistance in obtaining the samples of game animals for analysis, and to personnel of the U. S. Forest Service and the Plant Pest Control Division of the Agricultural Research Service for their help. Chemical analyses of samples were made by the following chemists of the Denver Wildlife Research Center: James E. Peterson, Milton H. Mohn, Richard A. Wilson Jr., and George H. Ise.

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DISCUSSION

MR. BALDWIN [Massachusetts]: I missed the early part of the paper. Did you make any tests on the deposition in the different areas and was there any correlation between actual deposition on the ground and the rate of DDT in game animals collected?

MR. FINLEY: The only measurement that we made was in the one area in the Porcupine Creek drainage in which one line of spray cards was laid out and samples of vegetation were clipped and several measured. After the spraying there were some deer collected from this area, but their movements were such that I do not think we could make any definite correlation between specific residues and the amounts on the cards. The cards merely showed us that the deposition along this particular line was approximately average, which was two-tenths of a pound per acre on the ground. Of course, much of the material that was released would undoubtedly be above the ground in the trees.

We do have plans to go into this problem by large enclosure studies. We have two possible areas in mind where there are 3000- or 4000-acre tracts already enclosed that we may be able to use and we will then know the deer or elk in these enclosures and they will be continuously in an area that is receiving uniform treatment. We hope this will clarify some of these variations we have been getting.

DR. DAVID KLEIN [Alaska]: It would be interesting to note the rate of elimination of residue from the body. Was there any attempt to analyze excreted material or the urine?

MR. FINLEY: We haven't anything on this except a few indications in samples of deer obtained a year later in which we did find small amounts present. There was only one that amounted to more than one part in a million. We are planning to go back to the two areas treated last summer in the next hunting season and obtain many more samples to help to answer this.

Information from livestock and other studies indicate there is a considerable elimination over a period of many months and normally in livestock there is a great bulk of materials eliminated within a year. However, we have found that some of the breakdown products are still present particularly metabolites of DDT, which we then call DDM. This appeared in our samples in the deer which were taken more than a year after the spray. I think the determination of these elimination rates is important, and I hope to get more on that.

As to the route of elimination, it has been normally believed that the principal route is through the conversion of the DDT eventually through DDE to DDA, which is eliminated in the urine. We know from other feeding tests and analysis of excrement that much of the material that appears in the excrement is usually in its original form. We did find both DDT and DDE in the excrement in rather large amounts. We think most of this went right through the tract and was not absorbed. I couldn't say what fraction it might be. There seemed to be some through perhaps the bile and some through the kidneys. These seem to be the principal routes of elimination.

TEN YEAR'S OBSERVATION OF AN ENCLOSED DEER HERD IN NORTHEN MICHIGAN[1]

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The purposes of this study were to determine (1) the population dynamics of a captive herd of white-tailed deer (*Odocoileus virginianus*) under comparatively natural conditions, (2) the ideal or maximum possible rate of exploitation, and (3) the ecological coaction between deer and the range in northern Michigan. Perhaps the most notable example of a similar study is that of the George Reserve herd in southern Michigan (O'Roke and Hamerstrom, 1948; Chase and Jenkins, 1962). However, the George Reserve and the Cusino Enclosure are almost complete contrasts in their original purposes, habitat conditions, and designs and results of deer investigations. This paper presents some highlights of the deer enclosure project from its inception in 1952 to date.

STUDY AREA AND METHODS

The enclosure is located at the Cusino Wildlife Experiment Station near Shingleton, which is about 10 miles from Lake Superior in

[1]A contribution from Federal Aid in Wildlife Management Michigan W-70-R and the Cusino Wildlife Experiment Station.

[2]The authors are deeply indebted to former biologist R. C. Van Etten, who was largely responsible for the data collected until 1960. This work was done under the supervision of D. F. Switzenberg, now retired from the Michigan Department of Conservation.

Michigan's Upper Peninsula. This locality is not far from the northern limits of the whitetail's range in the Great Lakes area. When Arctic air masses move across from the northwest, bitter cold and icy winds prevail; the snow-cover commonly exceeds three feet in depth. Normally, deer are confined to yards consisting of heavy coniferous cover for about 120 days. In this area as in northern Michigan generally deer numbers are limited by the quantity and quality of the winter range.

The enclosure fence consists of a double tier of four-foot woven wire stock fencing topped with four strands of smooth wire to make it 10 feet high overall. To our knowledge, only three deer have escaped; one deer broke through the fence and two jumped over it before the top extension was added.

The enclosed area is 647 acres. It is not quite square but nearly so. The site was originally selected because its broad cover types are closely representative of natural year-round deer range in this region. Altogether, the northern hardwood type comprised approximately 68 per cent, swamp conifer type 9 per cent, and open plains and semi-wooded area 23 per cent of the area enclosed. A permanent stream flows through the area from west to east. The creek produces some aquatic growth which is a source of summer food. During the winter deer sometimes use the stream for travel.

When the study began, 256 permanent plots were systematically laid out to enable us to analyze the vegetation and to check on changes caused by plant succession and deer browsing. On this basic plot design, several types of browse inventories have been used. These are the so-called Michigan method (Van Etten, 1955), the Aldous (1944) survey, and a modified version of the Passmore and Hepburn (1955) system. All the methods tried had some shortcomings in that none really provided the precise data desired. We have, however, attempted to maintain continuity in obtaining browse information by means of the various survey methods. In addition we established seven deer- and hare-proof exclosures in various cover types within the area.

Since its introduction, the herd has been inventoried several times a year by various methods. Most commonly we used the deer drive. This requires considerable manpower, readily available at the nearby Conservation Corrections Camp. Deer drives are made periodically, usually after leaf-fall and before leaf-out for best visibility. Each spring, during the peak of the fawning season, we diligently searched the enclosure for new-born fawns. We ear-tag, weigh, and release all young deer caught. The fawn census was very successful during the early years of higher population, when between 40 and 90 per cent of the fawns produced were handled each spring. Since the herd has been reduced in recent years, the searches have proved rather fruitless. We also search the enclosure each spring for remains of deer that may have died from accidents or natural causes, including starvation.

In the early years, it was difficult to make a complete accounting of all deer present in the fall population. In mid-winter we live-trapped as many deer as possible to examine them for ear-tags and physical condition. At this time part of the surplus deer were removed from the enclosure and released in the wild. Midway in the study we began to use a combination of trapping and shooting to obtain a complete accounting of the deer. All live-trapped animals were put in a small holding pen until all trappable deer had been captured. The few animals that eluded the traps were then hunted down and shot for identification.

Currently, we are placing colored aluminum collars (Fashingbauer, 1962) on all females. The color indicates the deer's age and should eliminate the need to kill deer during the trapout census.

In 1954 a detailed investigation into the mechanics of deer hunting on a known-size deer herd (Van Etten, 1957) represented a major addition to the objectives of the study. At times this effort took precedence over the original objectives.

Compared to winter live-trapping, hunting was desirable because it enabled us to remove surplus animals before they could make serious inroads into the vital winter browse supply. Conversely, however, hunting presented a major problem in that the age and sex of the kill could not be closely controlled and with a small, confined herd this proved critical. A few animals that were wounded in the hunts died later. Such inadvertent losses, together with other accidental deaths (mainly deer killed in trapping), in later years of low population tended to jeopardize the status of the original study. In 1960, it became necessary to restock the enclosure with wild deer to bring the herd up to a density comparable to outside densities.

RANGE ECOLOGY

The nature of the forest communities exerted influences on deer almost as profound as the herd did on the range. We should emphasize that the enclosure restricted a sizable herd of deer to a square mile of habitat for the entire year. Free-living wild deer normally concentrate in numbers in certain habitats as the seasons change. In winter, because of harsh weather, deer occupy only range suitable for yarding. Actually, the swamp conifer forest type ideal for yarding comprised only 10 per cent of the enclosure area. Probably because of its small size and relative isolation, deer did not naturally winter here before the fence was built. Consequently, at the start there was an abundance of food available, especially of high-quality white cedar (*Thuja occidentalis*).

At the start of the experiment, 25 species of woody plants were present in the enclosure. Ten of these were important because of their abundance or because of their nutritive value for deer: white cedar, ground hemlock (*Taxus canadensis*), red maple (*Acer rubrum*), sugar maple (*A. saccharum*), beaked hazel (*Corylus cornuta*), black cherry (*Prunus serotina*), balsam fir (*Abies balsamea*), juneberry (*Amelanchier* spp.), wild raisin (*Viburnum cassinoides*), and alder (*Alnus rugosa*). These 10 species accounted for 84 per cent of the stems with available browse.

In the first three years of study, deer markedly overbrowsed some preferred species. Ground hemlock, which was not abundant and is not resistant to browsing, was eliminated. Likewise, white cedar, which occurred only in the conifer swamp, declined by 80 per cent of its original abundance. The number of white cedar saplings (2-5 feet in height) was reduced by 85 per cent. Deer eliminated cedar reproduction promptly and efficiently. The trend in browse production for other species was definitely downward for each succeeding year. By 1959, after seven years of browsing, available food of all species had decreased by 85 per cent. However, the loss in browse production covered more than the 25 per cent of the enclosed area most heavily used by deer in winter. At the same time, vegetation analysis clearly showed that relative unpalatable, and unbrowsed, species had declined by 42 per cent. This reduction in browse produced by non-preferred plants strongly indicates that the natural growth of the forest was an important factor. After years of protection from cutting and fires, the canopy of the climax forest had closed sufficiently to shade out understory plants. Because of the rapid succession of vegetation from brush to trees, the carrying capacity of most northern Michigan range quickly declines, even without browsing pressure from deer. At this stage in forest growth, habitat management is necessary to slow down or reverse the cycle of food abundance to maintain a sizable deer herd.

HERD DYNAMICS

Productivity

Deer were placed in the enclosure in March, 1952. Three adult bucks were inadvertently confined in the enclosure when the fence was erected. Altogether 27 deer were enclosed: 5 adult males, 11 adult females, 2 juvenile males, and 9 juvenile females. In the first two fawning seasons, the gross productivity of enclosure deer amounted to approximately one fawn per doe (Table 1). Since these counts are based only on fawns actually examined, the fecundity rates represent absolute minimum figures. Net production as determined from fawns alive by early winter amounted to 21 of the original 26 observed. Some dead fawns were found during the spring searches and others tagged as newborn were never observed again. The cause of low fecundity in the initial two years cannot be appraised with certainty. Quite possibly, the low rates were a result of the relatively poor physical condition of the wild adult does introduced the first season and of the disproportionately high number of young deer (placed in the area as doe fawns) the following year (Table 2). There is little doubt that productivity among young and old females is considerably lower than that for does in the prime of life.

On the other hand, between 1954 and 1957 the gross observed fecundity ranged from 1.7 to 1.3 fawns per doe (Table 1). While part of the increase might have been due to a more favorable distribution of age classes, good year-round nutrition was undoubtedly important. In those years the deer were literally eating their way through

TABLE 1. FAWN PRODUCTION—CUSINO ENCLOSURE 1952-1962

Year	No. Adult Females	Fawns Per Doe		No. Fawns Produced	
		Gross	Net	Gross	Net
1952	11	1.1	0.8	12	9
1953	15	1.0	0.8	15	12
1954	12	1.7	1.5	20	18
1955	9	1.7	1.6	15	14
1956	8	1.3	1.0	10	8
1957	8	1.3	0.9	10	7
1958	7	1.1	1.1	8	8
1959	4	.75	0.5	3	2
1960	10[1]	1.3[2]	.6	13	6
1961	6	1.1	.6	7	4
Total	90			113	88

[1]Includes 7 does introduced from the wild.
[2]Beginning in 1960 gross productivity of the herd has been determined by X-ray.

TABLE 2. AGE DISTRIBUTION OF BREEDING DOES AND GROSS PRODUCTIVITY

Age of Doe	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
1½	3	8	1	2	1	4	2	1		
2½	2	2	6	1	1		3	1	1	
3½	5	1	1	3	1			2	3	1
4½		4	1	1	2				3	2
5½			3	2	3	3	2		2	1
6½										
7½									1	1
8½						1				1
Over 8½+	1									
Total does	11	15	12	9	8	8	7	4	10	6
Fawns per doe	1.1	1.0	1.7	1.7	1.3	1.3	1.1	.75	1.3	1.1

the lush white cedar and probably came out of the winter yard in excellent condition. Moreover, the quality of the summer and fall range had apparently not yet begun to decline.

From 1958 to 1961, however, over-all herd productivity dropped to about one fawn per adult doe (excluding the seven animals introduced in 1960, Table 1). At this stage the winter yard was severely overbrowsed, and there was some evidence that the habitat used in other seasons might be deficient in nutritive quality. We believe that at least some does saddled with nursing fawns during a summer were not in the best health at the onset of the breeding season. Other studies at Cusino strongly suggest that a doe's physical condition during estrus reflects summer range quality and has a strong influence on her fecundity.

Beginning in 1960, all does of breeding age have been X-rayed to determine their fecundity (Verme, Fay, and Mostosky, 1962). This technique has given us a definite measure of potential (*in utero*) fawn production. We can now appraise postnatal losses by comparison with the net production alive in the fall. In 10 seasons, for example, 90 adult does (including 8 introduced) had a minimum gross production of 113 young, for an average 1.26 fawns per doe (Table 1). However, 25 fawns, or 22 per cent, died before they were 6 to 8 months old, most likely at birth or very soon after. The mortality rate noted for enclosure fawns is about what we might expect from the nutritional status of the range (Verme, 1962). Such losses probably occurred because the doe was malnourished in winter and spring. A few fawns died accidentally or from predation.

Fall Population and Exploitation Rates. The true dynamics of the enclosure herd can be appraised only through 1959. After this we added new deer to the herd. In the early years, the fall population varied from 36 to 39, a density per square mile which probably exceeded that in the nearby wild. Although the herd was cropped to between 21 and 27 animals during winter, the surplus was not removed until mid-March by live-trapping, and as a result much of the limited winter browse was consumed. Beginning in 1955, a definite effort was made to reduce the fall herd to a density more in keeping with the lowered capacity of the habitat. From 1955 to 1961, most of the surplus was removed in the fall by controlled hunting. From 1956 to 1958, for instance, the overwinter population was held between 13 and 18 deer per square mile (Table 3), a much more practical level.

During the first 8 years of the study, the total removal was 101 deer. This was an average of 12.6 deer per square mile and is more than five times as great as the annual hunting season removal

TABLE 3. DEER REMOVAL AND NET FAWN PRODUCTION

Year	Spring Population	Net Fawn Production	Fall Population	Surplus Harvest	Total Removed	Per Cent Fall Population Recovered
1952	27	9	36	10	12	33
1953	24	12	36	12	15	42
1954	21	18	39	14	17	44
1955	22	14	36	15	18	50
1956	18	8	26	10	13	50
1957	13	7	20	5	7	35
1958	13	8	21	6	12	57
1959	9	2	11	3	7	64
Totals		78		75	101	
Means	18.4	9.7	28.1	9.3	12.6	46.8
1960	20[1]	6	26	9	14	54
1961	12	4	18[2]	9	9	50
Totals		88		93	124	
Means	17.9	8.8	26.9	9.3	12.4	47.9

[1]Includes 16 deer introduced from the wild. [2]Includes 2 adult males from the feeding pens.

in the Upper Peninsula as a whole. During this same period, the net production in the enclosure was only 78 fawns or 23 deer less than the number removed. On the average, the annual net increase amounted to 32.8 per cent of the fall population. The intentional harvest, which occurred primarily during the studies of hunting mechanics, amounted to 32.2 per cent of the fall population, or just slightly less than the average annual production. Since our objective during these years was to lower the population in keeping with the declining browse supply, some allowance was being made for accidental removals. However, the line was rather fine, and the magnitude of unavoidable accidents such as trap-losses, dog-kills, and crippling losses in hunting exceeded our estimates. The over-all removal rate averaged 46.8 per cent of the fall population. In 1958 and 1959, the unintentional mortality reached extreme rates and removal amounted to 57 and 64 per cent, respectively, of the fall population. The rate of removal was not of itself disastrous, but accidents distorted the sex and age ratios of the small herd to the extent that productivity was affected.

The fundamental reasons for the reduction of the enclosure deer herd were that (1) productivity declined after the winter range was overbrowsed and when the summer food supply deteriorated because of natural succession of the forest, (2) the rate of harvest did not adequately provide for the accidental or incidental losses that actually occurred, and (3) the removal produced an abnormal combination of age and sex ratios very significant in the small herd of later years. This third factor is one that is important only in small isolated herds and would not ordinarily be a problem in free-ranging herds.

FUTURE PROGRAMS

One shortcoming of this study stems from the original concept that we could perpetuate a sizable but restricted herd of deer on unmanaged northern Michigan range solely by harvesting the annual fall surplus. This concept did not take sufficiently into account the limiting effect of the small acreage of winter yarding area in the enclosure. Unfortunately, white cedar does not tolerate heavy browsing; and after this nutritious food was wiped out, the confined herd was in serious trouble. In late winter of 1958, two fawns apparently starved to death. Other symptoms of inadequate quantity and quality of browse in all seasons were also noted beginning in 1958. Yearling bucks with antlers shorter than the three-inch legal spikes began to show up in the fall kill. Small fawns and lighter-than-normal adult does lacking heavy deposits of body fat also indicate a chronic deterioration in range value. A few females apparently were non-productive, as evidenced by X-ray examination.

To rectify the range situation in 1960, we started a ''crash program'' to improve the habitat. Because the conifer swamp was too limited in acreage to cut over without greatly reducing its shelter value, the only alternative was winter cutting of timber around the periphery of the yard. This not only provided an immediate supply of browse from tops, but stimulated the growth of considerable natural food the following year. Thus far, we have clearcut small blocks of mixed upland timber distributed within the enclosure to produce an abunance of succulent sprouts and coppice. Later, when the food crisis is alleviated, we intend to place the entire area under extensive forest management, directed towards creating optimum deer range.

In addition, we are also devising and presently using more refined harvest and inventory techniques to achieve better control of herd composition and dynamics.

SUMMARY AND CONCLUSIONS

In view of our original objectives, we found that the population dynamics of the enclosure herd were such that on the average the annual increase constitutes 32.8 per cent (nearly a third) of the fall population. In early years when the range was in good condition, production was higher and a higher percentage of the herd could be removed. We found that accidents, predation, and other unforeseen losses would account for removal of about 12 per cent of the fall herd. In order to maintain the herd, a harvest goal approximating 20 per cent would permit a buffer against unforeseen losses. During the harvest, however, it is extremely important to give the utmost consideration to sex and age composition of the small isolated herd.

We also found the natural succession of the forest affected the carrying capacity of the enclosure almost as much as did pressure by the deer herd. Future range management in the enclosure will move the plant succession back to a stage that is productive of deer.

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DISCUSSION

A VOICE: Dave, I was wondering in this period of time what was the highest deer population at any one particular time during this period?

MR. ARNOLD: The highest number of deer we had in the enclosure at any one time was 39. This thing was set up with a study in mind not for esthetic purposes. This herd was never permitted to reach the spectacular levels that it did on the Georges Reserve in Southern Michigan. There were 39 deer per square mile within the enclosure, which was the most that was permitted.

EFFECT OF NUTRITION ON GROWTH OF WHITE-TAILED DEER FAWNS[1]

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This paper presents the results of experimental studies to determine the effect of various nutritional levels in white-tailed deer (*Odocoileus virginianus*) on pre- and postnatal growth of the fawn. Most workers have appraised the fawn's status under situations of generally adequate rations for the mother (Nichol, 1938; Cowan and Wood, 1955; Haugen, 1959; and others). Since many Michigan deer are commonly subjected to severe physical stress in winter because of acute browse shortages and harsh weather, the need for comparative vital statistics is quite obvious. This investigation was conducted from 1954 to 1962 in Michigan's Upper Peninsula. In nine years I obtained reproductive records on 203 captive, pregnant does that produced 312 young.

I wish to thank Michigan Department of Conservation Game Division colleagues for valuable help in various phases of this project and report, especially H. D. Ruhl, R. A. MacMullan, D. W. Douglass, and D. F. Switzenberg, now retired.

STUDY METHODS

Experimental layout, herd composition, and feeding regimen for this study were reported in detail earlier (Verme, 1962). To reiterate briefly, I maintained groups of adult does in small pens during winter and spring. In winter the animals were fed prescribed rations consisting principally of natural browse over a 100-day period which essentially corresponds to the typical deer yarding season in this region. By controlling the quantity and quality of food, I provided high, moderate, and low-value diets. Consequently, at the end of the trials, mean losses in body weight amounted to approximately 5, 16, and 26 per cent, respectively. In contrast to the excellent vigor of does on plentiful rations, by the end of the winter trials deer on extremely poor diets were very thin and weak from hunger.

In spring I switched the ration to Kellogg deer pellets and regulated the feeding of pellets to provide high, moderate, and low nutritional levels. To simulate natural food conditions, I raised the ration slightly at bi-weekly intervals during the spring. Differences in feed allotment among deer were greatest early in the season, but as time progressed the disparity gradually diminished. By mid-June,

[1]A contribution from Federal Aid in Wildlife Restoration Project W-70-R and the Cusino Wildlife Experiment Station.

at the peak of fawning, all deer received the same ration, essentially a high level. In July the nursing does were fed all they would eat.

Winter-spring nutritional combinations used to test the effects of different planes on pregnant deer are as follows:

Dietary Group	Winter Nutrition	Spring Nutrition
I	High	High
II	Moderate	High
III	Low	High
IV	Low	Moderate
V	Low	Low

Unquestionably, the relative degree of stress incurred by does increased in direct proportion to the decline in dietary plane. The effects of malnutrition were thus most pronounced for animals whose period of fasting extended into mid-spring—the lower groups.

To correlate the mother's health status with that of her fawn, newborn young were promptly weighed and measured, and ear-tagged. Physical development, or size, at birth was ascertained by measuring the fawn's body length (top of nose to posterior tip of sacrum along the spine), hind foot (point of hoof to tip of calcaneum), ear span (apex to inner notch), and head width (groove behind postorbital process on frontal bone). Fawns were weighed on a dial scale to the nearest two ounces. Thereafter, I weighed them weekly until they were four weeks old. Beyond that age they were much too fleet afoot to capture without risk of injury. Primarily because of heavy natal and early post-partum losses, the number of fawns available for weighing declined slightly each week. A few animals were shifted to another phase of the study before they were a month old.

In addition, I obtained 97 fetuses, including 21 of known age, from experimental deer. These fetuses were mainly from does sacrificed for autopsy; however, a few mothers had starved in winter. To supplement this sample, I examined specimens from wild, road-killed does from the Cusino area. Most fetuses were inspected in fresh condition; a few were preserved in 10 per cent formalin. Forehead to rump (F-R) length in millimeters was measured on all fetuses. Weights of small fetuses were taken directly in grams; that of large specimens in ounces, later converted to grams. Approximate age of the fetus was determined according to the key in Armstrong (1950).

INFLUENCE OF NUTRITION ON FETAL DEVELOPMENT

Normal Growth Curve: To my knowledge no one has investigated whether fetal growth is influenced by physical condition of the mother. Conceivably, such relationships could be of considerable

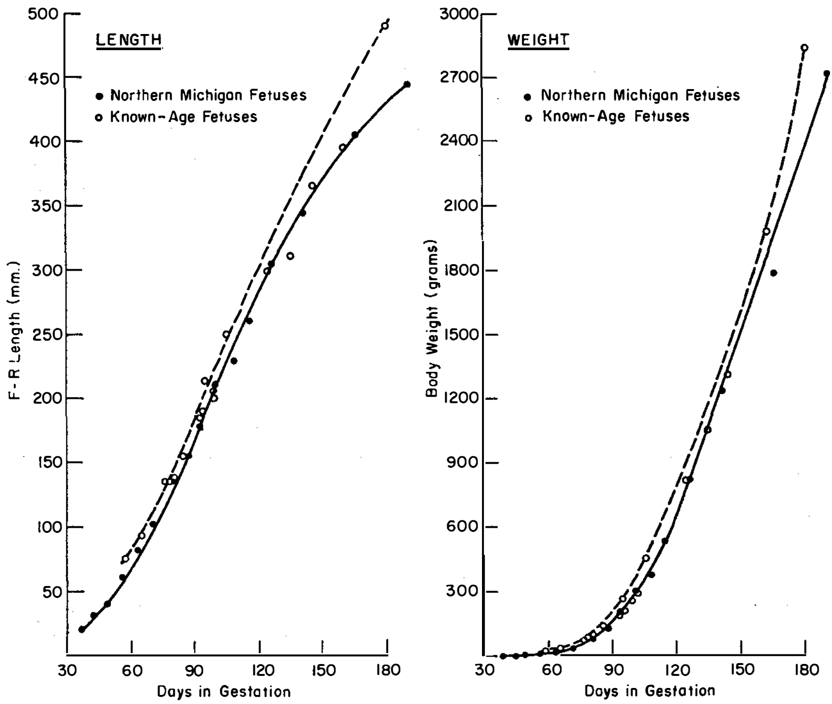

Figure 1. Growth Curves for 316 Northern Michigan fetuses compared to 21 known-age specimens; curves eye-fitted.

diagnostic value in predicting natal fawn mortality rates according to range carrying capacity. To ascertain the normal pattern, initially I constructed growth curves based on a total of 316 fetuses from northern Michigan does. Figure 1 presents the mean F-R lengths and body weights plotted by mid-point dates for 16 fetal age classes. For comparative purposes, growth curves of 21 known-age specimens (included in the composite sample) are shown separately. These fetuses were taken from does in excellent health when sacrificed. Fetal data for the average sample represent all stages of physical condition among mothers, from very good vigor to extremely poor. As expected, therefore, at respective stages in gestation the known-age specimens are slightly larger than average, especially near the end of the cycle.

With respect to the validity of Armstrong's (1950) aging criteria, I concur with Palmer (in *op. cit.*) that the key tends to underage some fetuses. Although I lack definite proof, in my opinion the pace at which external features evolve is largely independent of the fawn's relative vigor (except, perhaps, when the death of the fetus or mother is imminent). This contention is basic to the interpretation of findings in the following discussion.

Weight Variations of Fetus and Uterus: Like other animals, most of the growth of the deer fetus takes place in the last third of gestation. Clearly, the quantitative demands for nutritive materials in the mother are rather small at first, but they progressively increase to become several times as large toward the close of the period (Maynard and Loosli, 1956). Pregnancy is known to increase the need for protein much more than the need for energy. If the diet is inadequate in all respects, the mother sacrifices her bones and body tissues to nourish her fetus. After a prolonged siege of malnutrition and bitter cold weather, however, the doe's reserves may be small or non-existent (Kitts, *et al.,* 1956). If this is true, the fetus might be radically affected by insufficient essential nutrients as it approaches term.

To check this assumption, I sorted the autopsy records for does which carried fetuses at least 121 days old, with respect to the mother's relative vitality at time of death. Deer that had appreciable internal fat and a femur fat content of at least 50 per cent (Cheatum, 1949) were assigned to a good vigor class. Does whose health index fell below these standards were placed in a poor group. In experimental deer, recourse to body weight data provided a factual basis for appraising physical condition.

Altogether, 137 fetuses were old enough to be suitable for this analysis. Examination of Table 1 reveals that at about 133 days' gestation, inadequate nutrition begins to retard fetal development. Beyond this time, growth in length and (primarily) weight of fetuses from impoverished does falls rapidly behind that of normal young. At approximately 151 to 180 days, for instance, differences in F-R length and weight between good and poor fetuses amount to about 30 millimeters and 830 grams, respectively. Interestingly, size differences in the final 20 days of gestation are less pronounced. However, no fetuses from half-starved penned deer are present in this age group, in contrast to appreciable numbers of such specimens in the younger classes.

Concurrent with this work, I weighed unopened uteri from pregnant does to determine the relation of total biomass to that of fetuses inside. This was done by severing the reproductive tract at the cervix and cutting away connective tissues and ligaments. By means of the scheme described earlier, I segregated the data for 44 does in the last third of pregnancy.

TABLE 1. RELATION OF FETAL DEVELOPMENT TO PHYSICAL CONDITION OF DOES

Gestation Age Class (Days)	Physical Condition of Does[1]	Fetuses Examined	Mean F-R Length (mm.)	Mean Weight (grams)	Growth Factor[2]
121-132	Good	14	304	823	2.50
	Poor	20	312	810	2.53
133-150	Good	18	345	1360	4.67
	Poor	25	342	1101	3.77
151-180	Good	8	410	2410	9.88
	Poor	28	379	1579	5.98
181-200	Good	14	447	2851	12.74
	Poor	10	440	2543	11.19

[1]See text for method of determining physical condition.
[2]Arbitrarily computed as length $\times$ weight $\times$ 10^{-5}.

TABLE 2. EFFECT OF DOE PHYSICAL CONDITION ON FETUS AND UTERUS WEIGHTS[1]

Gestation Age Class (Days)	Physical Condition of Doe[2]	Uteri Examined	Mean Weight		F/U Ratio	Uteri Examined	Mean Weight		F/U Ratio
			Single Uterus	Single Fetus			Twin Uterus	Twin Fetuses	
121-132	Good	3	2363	756	.320	3	4120	1607	.390
	Poor	2	2211	836	.378	2	3742	1389	.371
133-150	Good	1	3175	1049	.330	5	5807	2682	.462
	Poor	3	2344	1002	.427	7	3986	2075	.521
151-180	Good	1	4028	1928	.479	3	9223	5160	.559
	Poor	2	3772	1375	.365	6	5670	3298	.582
181-200	Good	2	5330	3233	.607	1	12587	6922	.550
	Poor	1	6917	4423	.639	2	8051	5051	.627

[1]Weight of unopened uteri and fetuses in grams.
[2]See text for method of determining physical condition.

Table 2 reveals that at respective stages the weights of an intact uterus and its single fetus are not consistently different between does in good and does in poor vigor. On the other hand, data for twins plainly show a sizable advantage, both in uterus and fetal weights, in favor of well-fed deer. Oddly, the fetus/uterus ratio ordinarily is much higher than normal among unthrifty deer, particularly for those with twins. The findings suggest to me that although other physiological factors may be involved, the uterine fluids may not be produced or maintained at regular levels among does subjected to malnutrition. Unfortunately, I did not measure the uterine fluids while removing the fetus.

Obviously, insufficient prenatal nutrition markedly slows the growth of fetuses so as to be readily measurable. The practical implications of these findings are considerable.

SIZE OF FAWNS AT BIRTH

Dietary Plane and Fawn Size: Birth weights of 201 fawns (excluding 14 atrophic fetuses carried to term) from this study show an extreme range of from 2.0 to 10.1 pounds in which the average was 6.5 pounds. However, size of newborn fawns varied extensively, depending primarily upon dietary plane of the mothers. For example, mean

TABLE 3. MEAN BIRTH WEIGHT AND SKELETAL SIZE OF FAWNS[1]

Dietary Group	Fawns Examined[2]	Weight (Pounds)	Body Length	Head Width	Ear Span	Hind Foot
I	67	7.8 ± 1.2[3]	24.1	2.22	3.32	10.7 ± .6
II	49	6.8 ± 1.2	22.5	2.19	3.27	10.3 ± .6
III	36	5.8 ± 1.6	21.6	2.15	3.21	9.9 ± .7
IV	35	5.4 ± 1.9	21.4	2.14	3.13	9.5 ± 1.0
V	14	4.2 ± 1.2	19.9	2.10	2.86	8.7 ± .8
Means and Total	201	6.5 ± 1.4	22.5	2.18	3.22	10.1 ± .7

[1]See text for manner of measuring skeletal size; data are in inches.
[2]Excluding 14 dead fetuses carried to term.
[3]Standard deviations.

weight of 67 fawns from high-diet Group I deer amounted to 7.8 pounds, as against 4.2 in 14 group V young dropped by malnourished does (Table 3). Compared to Group I animals, fawns from Group II were 12 per cent lighter, Group III weights were 28 per cent lower, and fawns from Groups IV and V weighed 31 and 46 per cent less, respectively.

Moreover, skeletal growth of fawns also was inhibited by *in utero* nutritive deficiencies, although not to the same extent as weight. Hind foot (hock) length, probably the best indicator of frame development, varied from a mean of 10.7 inches in Group I fawns to 8.7 in Group V progeny, a difference of nearly 19 per cent. Measurements for body length, head width, and length of ear likewise confirm the fact that fawns born to improverished does tend to be runty and emaciated.

Inevitably, a fawn's life expectancy closely hinges on its size at parturition. Examination of data for Groups III, IV, and V—deer on low diets—serves to illustrate this point. As the production of progressively smaller and lighter (from $\bar{x} = 5.8$ pounds to 4.2) offspring increased, the respective mortality rates rose from 35 to 93 per cent of the crop (Verme, 1962). Surviving fawns averaged 6.4 pounds at birth, over 2 pounds heavier than those that died. Conversely, fully developed but stillborn young weighed only 3.3 pounds on the average as against 4.4 for progeny born alive but dying from nutritive failure within 48 hours. Finally, fawns dropped before the peak of parturition weighed 4.9 pounds and suffered 70 per cent casualties, compared to 5.8 pounds and 35 per cent mortality among those born later.

Although the rations were gradually raised to a high level in late spring, it is quite evident that dietary improvement came too late to help most of the underfed does. Experiments on sheep have conclusively shown that the pregnant ewe must receive a high plane of nutrition is she is to produce large, healthy lambs of which few die, in contrast to the weak, small lambs and high losses that result when

TABLE 4. INFLUENCE OF NUMBER IN LITTER ON FAWN WEIGHT

Dietary Group	One Fawn	Two Fawns	Three Fawns
	Mean Weight (Pounds)		
I	8.4 (20)[1]	7.8 (41)[2]	6.3 (6)
II	7.3 (13)	6.7 (36)	
III	6.3 (15)	5.4 (21)	
IV	6.8 (10)	4.8 (22)	5.1 (3)
V	4.8 (8)	3.5 (6)	
Means and Totals	7.0 (66)	6.4(126)	5.9 (9)

[1]Numbers of fawns examined are shown in parentheses.
[2]In four sets, one twin was atrophic and therefore not weighed; thus, the number of fawns is not always divisible by two.

ewes are improperly fed (Thomson and Thomson, 1948, 1953; Wallace, 1948).

Relation to Natural Factors: As a rule, a single fawn is approximately a half-pound heavier at birth than one of twins (Table 4). The spread in weight tends to widen progressively from Group I to Group IV. Naturally, a poorly-fed doe carrying twins is much more hard-pressed to provide even minimal sustenance compared to a mother with one fetus. This is tellingly illustrated by the fact that Group I twin fawns were more than twice as heavy at birth as those in Group V, compared to 75 per cent greater weight of a Group I single fawn over a Group V single.

Fawns from multiple litters often vary appreciably in size. Thus it seems reasonable to conclude that as prenatal stress intensifies there may be an unequal division of nutrients among individuals. Perhaps this physiological tendency enables one fawn to be salvaged when the probability that both young will survive is very remote. Since Group V newborn twins did not differ substantially in size, however, there is an indication that when a doe reaches a crucial level in physical condition, inequality in growth probably is unimportant as both progeny are doomed.

Collectively, data for 92 males and 109 females show no consistent differences in weight for all litters (1, 2, and 3 fawns). Among 66 singles, the average female was somewhat heavier than the male; however, nearly half of the females were exceptionally large Group I individuals. On the other hand, mean birth weights for 126 twin fawns definitely favor males over females by nearly a half-pound. To some degree, the weight differential increases slightly from Group I on, a possible suggestion of innately better resistance to prenatal hardships among males.

Single fawns produced by 2-year-old versus prime-age (3 to 7 years) does did not differ substantially overall. Within a dietary group, however, the average individual from older mothers ranges from a few ounces to over a pound heavier. In general, the size

TABLE 5. GROWTH RATE OF FAWNS

Dietary Group	Birth	7 Days	14 Days	21 Days	28 Days	Rate of Gain
	Mean Weight (Pounds)					
I	7.9 ± 1.3[1] (60)[2]	11.7 (60)	14.1 (54)	17.6 (51)	21.1 ± 2.7 (49)	2.67
II	6.9 ± 1.3 (45)	10.5 (45)	13.3 (38)	16.5 (37)	19.8 ± 2.9 (34)	2.87
III	6.4 ± 1.3 (23)	10.6 (23)	13.5 (23)	17.1 (22)	20.4 ± 2.1 (16)	3.19
IV	6.3 ± 1.7 (19)	9.9 (17)	12.9 (19)	16.8 (16)	19.9 ± 2.6 (16)	3.16
V	5.8 (1)	9.9 (1)	14.0 (1)	17.6 (1)	21.5 (1)	3.71
Means and Totals	7.1 ± 1.5 (148)	10.9 (146)	13.6 (135)	17.1 (127)	20.4 ± 2.8 (116)	2.87

[1]Standard deviation.
[2]Numbers of fawns examined are shown in parentheses.

spread increases as the plane of nutrition declines. This is entirely logical and understandable; compared to older deer, 2-year-old does are still physically immature. Consequently, young mothers probably are much more vitally affected by chronic food shortages, especially during late pregnancy.

EARLY POSTNATAL GROWTH OF FAWNS

Growth Rate and Dietary Plane: Inspection of Table 5 suggests a small paradox: Postnatal growth rate of fawns in this study is inversely correlated with the dietary level of the doe. For example, Group I progeny averaging nearly 8 pounds at birth grew to about 21 pounds in four weeks, an increase equal to 2.67 times original size. Concurrently, Group III fawns increased from 6.4 to 20.4 pounds, or 3.19 times the original size. Since fawns in other dietary groups also manifested differential growth, despite the initial spread, the weight difference ceased to exist at four weeks for all practical purposes.

Primarily because of heavy natal mortality, surviving Groups III, IV, and V fawns were considerably larger than average (see Table 3). Still, I doubt that natural selection, in which unfit specimens were ruthlessly weeded out, entirely explains the situation of very rapid growth among surviving fawns. It should be emphasized that although the food allotment was raised throughout the parturition season, many Groups I and II offspring were born before the mother's ration was at a high level. In contrast, most early-born Groups III to V fawns died; hence, most of those that lived were dropped after the peak partum date.

Perhaps most important, Groups I and II deer nursed an average of 1.58 fawns per doe during the first month, as compared to 1.32 young each for mothers in Groups III-V. While nearly 60 per cent of the high-diet does reared twins, only a third of the mothers on poorer levels nursed two fawns. Consequently, Groups I and II mothers were commonly saddled with early-born progeny, larger fawns, and more of them. Under these circumstances, the heavily burdened lactating doe may not have been able to produce sufficient milk, in terms of pounds of milk per pound of fawn, to properly suckle her offspring.

As stated above, small fawns grow proportionately faster than very large newborn young. Analysis of relative growth rate, presented in Figure 2, is based on continuous data for the 116 fawns available throughout the weighing period. The appraisal is in relation to eight birth classes (3.0-3.9 pounds, 4.0-4.9 . . . 10.0-10.9), combining similar data for all dietary groups. Evidence of growth variations due to birth size is gleaned from the fact that small, medium, and large fawns ($\bar{x}$ = 3.8, 6.5, 9.4 pounds), respectively increased 4, 3, and 2½ times in weight during the initial four weeks. Yet, despite a tendency toward compensatory growth among originally small individuals, the final weight span was still considerable (Figure 2).

These findings probably represent a natural growth phenomenon; e.g., compared to undersize newborn young, it might be physically impossible for extremely big fawns to make a four-fold weight increase in one month. As shown by Table 5, most of the smaller, hence faster-growing fawns were produced by deer in Groups III to V. The operation of this factor in concert with other variables mentioned undoubtedly explains the seeming contradiction in pattern of growth response manifested by fawns per dietary group.

Effect of Litter Size and Sex on Growth: Surprisingly enough, relative growth rate was slightly slower for single fawns than for twins; however, fawns from one birth were somewhat larger to start with, and at four weeks old. Single fawns reared by 2-year-old does grew a shade faster than those nursed by prime-age mothers, but they were born smaller and generally dropped later. The best weight gains were made by the lone survivor from a multiple litter decimated by heavy infant mortality. This is expected, since a physically mature mother dropping twins or triplets certainly is capable of nursing her sole living fawn at an optimum level.

Although mean birth weights of 51 male and 65 female fawns were virtually identical, in one month the males were nearly a half-pound heavier. Single males grew a bit faster than single females which were larger initially. On the other hand, among mixed twins the females led in rate of gain by a scant margin. This indicates that the bigger, and perhaps more aggressive, males do not necessarily get the lion's share of the mother's milk. Nevertheless, I commonly observed that one individual of twins promptly out-

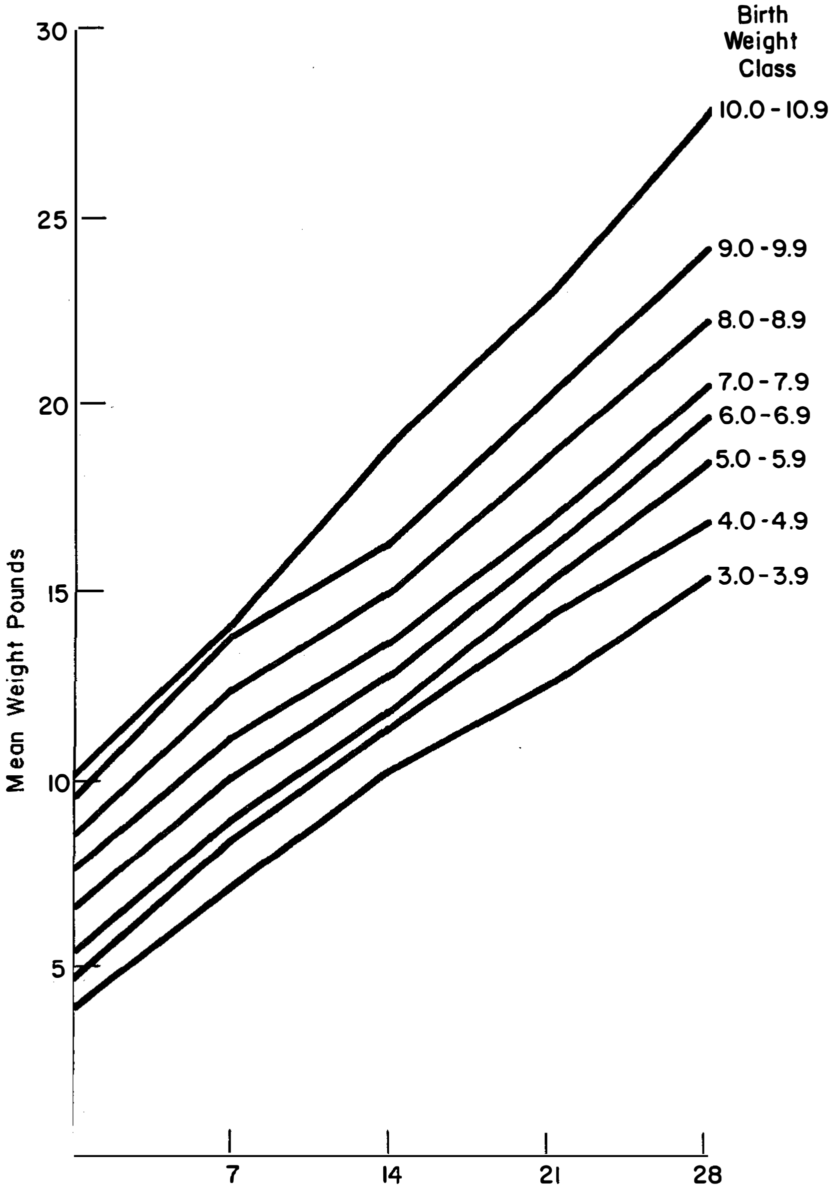

Figure 2. Relative growth according to birth weight class of fawns.

strips its litter mate in growth, hence in ultimate size, even though their starting weights are similar.

LACTATION STRESS AND FAWN METABOLISM

Growth of whitetail fawns closely resembles that noted for black-tailed deer (*O. hemionus columbianus*) by Cowan and Wood (1956). The average fawn in this study gained nearly a half-pound per day during the first month, although the rate of increment was slightly greater among large fawns. During their second week, most fawns experienced rather sharply reduced growth; however, the normal pace was quickly recovered (Figure 2).

When about two weeks old, fawns begin eating solid food, which may enable them to offset a possible shortage of milk. Actually, I strongly doubt that milk yield varied appreciably with respect to the doe's earlier dietary status. However, Thomson and Thomson (1953) report that milk yield of the ewe is closely dependent upon her nutritional level during late pregnancy and *during* lactation. Chemical analysis of milk samples from does in this study likewise failed to reveal differences in constitutents that could be directly related to winter and spring nutritional levels (Verme, Youatt, and Ullrey, 1962). Plainly, if the doe gets sufficient food to support lactation, her milk will be of excellent quality; thus, the fawns will make extremely rapid growth.

From their hungry behavior, many does suffered from physiological stress during the second week of lactation, particularly if the young were dropped early. In the first three weeks of lactation, the mother's blood picture shows little if any improvement, or it may deteriorate slightly (Verme, Youatt, Ullrey, *op. cit.*). Ordinarily, heavily-producing deer lose some body weight during this period, particularly those rearing twins. As in the case of the cow (Maynard and Loosli, 1956), it frequently is impossible to get the nursing doe to consume enough food to compensate for her total energy expenditure.

Kitts, *et al.* (1956) postulate that inadequacies in lactation because of earlier malnutrition in the doe may increase postnatal mortality because the fawn's normal growth is impaired. Similarly, Cowan and Wood (1955) suggest that a temporary setback in the fawn's growth due to unusual circumstances may sometimes lead to relatively major upsets in the regular pattern. However, I see no indication that a brief nutritional disorder critically affects the health of fawns. The nursing does and her progeny are remarkably hardy animals and they are inherently resistant to environmental pressures. There is little evidence that Michigan's summer range ordinarily is limited in quality or quantity of browse. Nevertheless, the great value of lush-quality habitat is quite apparent. Drastic food shortages in other seasons are much more important in controlling the biology and population dynamics of deer.

SUMMARY

Experimental feeding trials were conducted on penned, pregnant does in winter and spring to determine the effect of various dietary planes on pre- and postnatal development of white-tailed fawns. Malnutrition in the mother results in retarded length and weight growth of her fetus beginning at about 133 days' gestation. At birth, fawns from nearly starved mothers average about 46 per cent lighter, and they tend to be stunted skeletally, compared to young from well-fed does.

Early postnatal growth rate in fawns in this study was inversely related to the does' earlier nutritional status. In contrast to malnourished deer, properly-fed mothers incur a proportionately greater lactation burden because they have bigger young, suckle more twins, and successfully rear their early-born offspring. Initially tiny fawns experience a faster, or compensatory, rate of growth compared to very large young. Hence, despite the original disparity in weights, because of the coaction of various biological forces, the size gap may be practically non-existent at four weeks old. Fawns grow very rapidly and most of them roughly tripled in weight in the first month.

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DISCUSSION

DR. DAVID KLEIN [Alaska]: This is a very interesting paper that certainly answers a lot of our previously unanswered questions about nutrition.

Regarding your summer diet, since these rations were of the same nutritional quality but of a variation in quantity, I am wondering if this perhaps is not different than what actually exists on the range at that time of the year when quantity is very seldom limiting but quality is perhaps limited.

MR. VERME: I think you are right. Unfortunately, because of the experimental procedures required, it was impossible to vary the quality of the food. We simply varied the total energy of the rations. I couldn't speculate as to what would happen if you varied the quality. I am sure the result would be somewhat similar. We have no information on that.

DR. PETERLE [Ohio]: Would you comment briefly on the difference in the losses of the sexes? Did you find any particular losses in either sex?

MR. VERME: I have only scanty data on prenatal and postnatal fawn losses with regard to sex. I hesitate to mention this because my results are generally contrary to what is believed to be a normal picture in most animals and this includes the white-tailed deer. I found that there seemed to be a higher loss in the female fawns than the male fawns. Why, I don't know. I don't know if this is really a true picture. Many other studies on domestic animals have shown the male presumably suffers a disproportionately higher mortality *in utero*. However, I cannot substantiate that.

DEVELOPMENT OF RADIO-TELEMETRY TECHNIQUES FOR RUFFED GROUSE STUDIES[1]

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Wildlife biologists have expressed growing interest in using radio-telemetry techniques to attack ecological problems basic to management and there are many projects in the United States and Canada working to this end. "Grousar," a project which is developing radio-telemetric methods for ruffed grouse (*Bonasa umbellus*) studies is now in its fifth year. This paper discusses the background, stages of development, the electronic systems, field techniques, and examples of data obtained through June 1962. Some comments on potentials of this technique are given.

Problems pertaining to the distribution of animals in time and space have been attacked by using various methods to mark animals for identification. The normal aspect of an individual animal has been altered by adding devices (bands, tags, etc.) or by changing physical parts (dyeing, toe clipping, etc.). Such techniques have

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required direct observation or actual handling of the animal for identification (Cottam, 1956; Taber, 1956). Recently radio-isotopes have been used to mark animals but these individuals cannot be distinguished from each other. (Tester, 1963). The development of miniature radio transmitters that animals can carry allows marking with a discrete radio frequency (RF) which offers a means for both *remote* location and identification of individuals. The design of a transmitter small enough to be easily carried by a ruffed grouse and still provide useable electronic characteristics of range and signal life was a major challenge.

Male ruffed grouse were chosen for the developmental phases of this study for three reasons: (1) They could be obtained by mirror trapping and so provided a ready supply of animals for experimenting with the technique (Marshall, 1963). (2) Recapture of individuals carrying transmitters for purposes of physical examination or battery replacement was possible. (3) Of most importance, we were relatively certain that, once released with a transmitter, they would remain in a fairly small area or activity center (Gullion, King and Marshall, 1962) during intensive studies. This reduced logistic problems in the deployment of receiving equipment.

The first phase of the project, involving the development of transmitters and receiving systems by contract with a commercial concern, began in January 1959. This was an expensive process and the equipment was not entirely satisfactory. In fact, when we found that these transmitters were not suitable for ruffed grouse we turned to the porcupine (*Erethizon dorsatum*) as an experimental animal and learned much about field problems in the use of radio positioning techniques (Marshall, Gullion and Schwab, 1962).

The second phase of this project was carried out between September 1960 and June 1962. During this period transmitters that could be carried by a ruffed grouse were made and portable receiving equipment with suitable directional antennae were built and tested. Methods of attaching the transmitter to the ruffed grouse were developed and tried on seven experimental birds in February and March of 1962. In April, six males were equipped with transmitters and the movements and activities of three of these were studied 28, 29 and 32 days. The techniques and systems developed during this phase have been recorded on film and a 16-minute documentation is available.

A third phase, studying both males and females, is being carried out during the 1963 breeding season using these techniques and some improved equipment.

EQUIPMENT DESIGN, USE AND PERFORMANCE

In the "Grousar" project we are using three major kinds of equipment—transmitters to be placed on the grouse, receiving equipment with directional antennae, and a Citizens Band (CB) communications system for the coordination of field work. Since new electronics equipment is being constantly developed, we do not consider this system or the techniques to be final. In fact, during the work going on in 1963, we are using portable receivers which are improved by adding a meter for visually reading the audio output after it has passed through the audio filter. Also the weight of the transmitters has been reduced. It is hoped that in the near future the merits of using this VHF system (151 Mc/s) can be compared with those of systems using other wave lengths.

Transmitters—We have developed continuous (AO) broadcast transmitters with a maximum power of .01 watt which operate at discrete frequencies in the VHF range (150.815-151.085 Mc/s). These frequencies were chosen to provide a short transmitting antenna and make possible the use of unidirectional yagi type antennae. Also this particular wave length was available for experimental purposes under FCC regulations.

The transmitters employ a micro-alloy diffused transistor in a crystal oscillator circuit. A fifth overtone crystal is used which operates at one-half the output frequency. The second harmonic outnut is increased by having a second tuned circuit in the collector which is tuned to twice the crystal frequency. Input to the oscillators varies from 100-300 micro-watts. The units are encapsulated in epoxy resin to make them durable and waterproof and their outside dimensions are 31 mm long, 19 mm wide and 13 mm deep. The weight is 12 grams.

The antenna is a fine spring wire .009 inches in diameter and 8 inches long which extends over the back of the bird.

Each transmitter is powered by a mercury battery (Eveready 640 or Mallory RM 640) which weighs 8.8 grams and is 12 mm in diameter. This power source will operate these transmitters for 60-75 days depending on the power requirements of individual transmitters.

This equipment operated on birds at ambient temperatures from —20° F. to 85° F. Precipitation did not affect their performance adversely.

The transmitter package (battery and transmitter) is ventrally suspended by a light and durable yoke-like harness designed to fit the body contour of the bird and allow complete freedom of move-

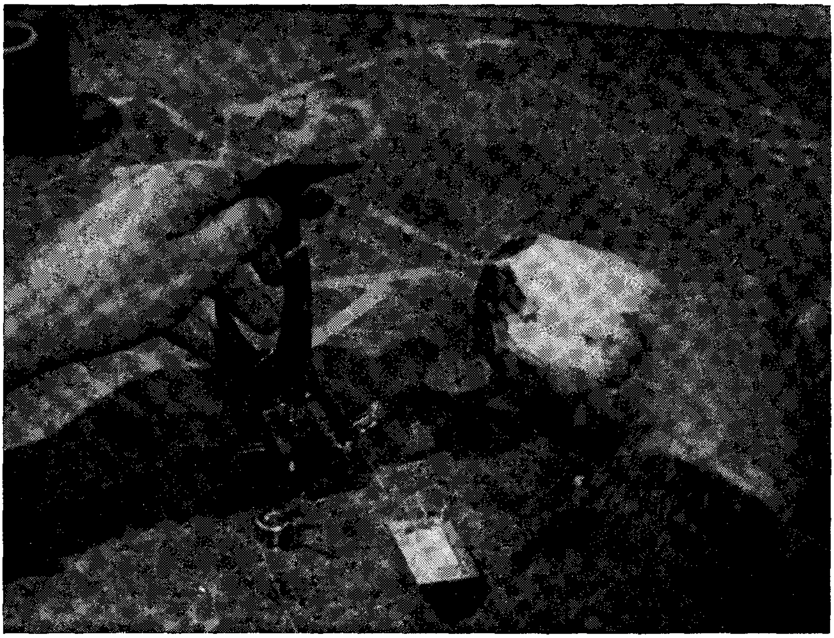

Fig. 1. Close-up of harness, battery, and transmitter with wooden dummy used to shape harness.

ment. The harness is composed of four parts—a dorsal plate, yoke, lateral straps and ventral carrier (Fig. 1). With the exception of the lateral straps which were of fiber glass cloth, the harness is made of electrical tape and weighs 8-10 grams. The total weight (transmitter, battery, harness) added to the bird is 30 grams at maximum.

The harness is placed on the bird by slipping the yoke part over the bird's head so that the dorsal plate rests on the scapular region of the back, and the ventral carrier on the breast muscles (Fig. 2). The ventral carrier is held against the bird by inserting the lateral straps through slots in the dorsal plate and drawing them up snugly. The straps are stapled to the dorsal plate and excess strap material cut off. The feather tracts overlaid by the yoke-harness are pulled over it so that only about half of the dorsal plate and ventral carrier are exposed.

We have equipped 13 grouse with transmitters and on many occasions compared their activities and behavior to that of other grouse. No behavioral differences were apparent when transmitter harnesses properly fit the birds carrying them. However,

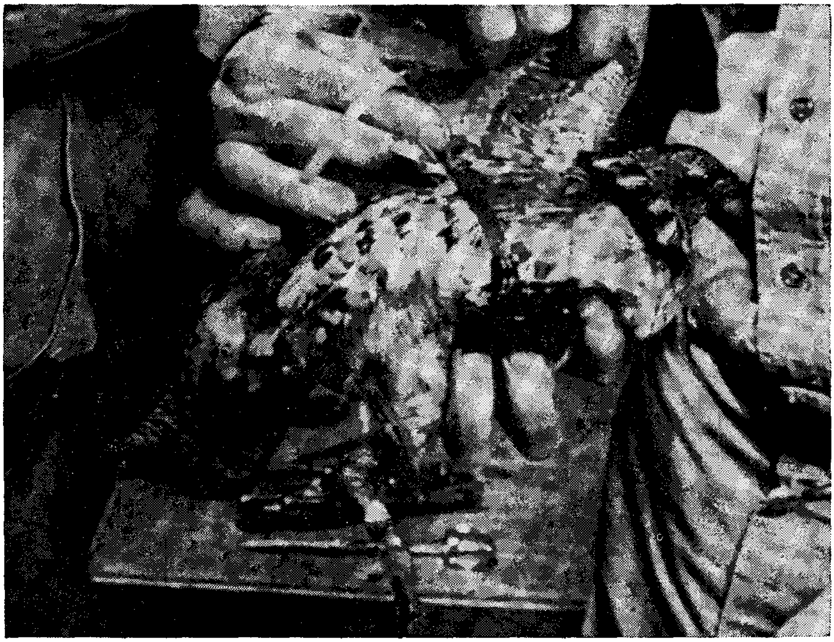

Fig. 2. Closeup of transmitter-battery package on grouse showing lateral straps and ventral position of transmitter package.

harnesses that did not hold to the body contour of the bird irritated the birds' skin causing them to react abnormally.

Observation of RF-marked birds purposely flushed from the ground, out of snow burrows in thick cover and from tree tops indicated no difficulties in flight. Undisturbed birds with transmitters flew readily up into trees where they were observed feeding on buds and catkins. During the breeding season, males with transmitters drummed with the same frequency and audio-effect as their non-transmitter equipped neighbors although dropping counts indicated log attendance may have been reduced. In February and March, predation on birds with transmitters was about the same as on the rest of the population. During April and May five male birds carried transmitters a total of 116 days and suffered no predation although horned owls, goshawks, and red fox were known to have been in the study area.

Receiving Equipment—The equipment used for signal reception consists of portable receivers used with temporary, mobile-mounted or hand-held directional antennae and a non-portable receiver used with a temporary antenna.

The non-portable receiver is an NC-188 communications receiver converted to VHF reception by an XC-144 Tapetone converter. It is used with an SA-3 Panadapter, and a temporary directional antenna. Power for this unit is provided by a portable 500 watt AC generator. This receiving system is housed in a small two-wheel trailer to retain a modicum of mobility and provide shelter for the operator.

The portable receiver is small (5 x 6 x 9 inches), lightweight (4¼ pounds) and easily transported. It is a channelized, crystal controlled, double conversion unit of the superheterodyne type, completely transistorized for economy of size and weight. The radio frequency amplifier, first converter and beat oscillator are custom made while the first IF amplifier, second converter, second IF amplifier and detector as well as the audio-amplifier are available commercially as a single unit. The first converter switches to any of six crystal controlled channels. Nine flashlight batteries (size C) in series will run the receiver over 100 hours. Receiver sensitivity provides a useable signal at 1/10 microvolt input. Screw couplings on the receiver allow connection to earphones and the RF cable of the antenna being used.

Use of the portable receivers at temperatures down to —20° F. showed that their efficiency was reduced when ambient temperatures dropped below 22° F. To prevent the transistorized circuit from being influenced by low temperatures during cold weather receivers were kept in an insulated shoulder sack with one or two handwarmers.

The portable receiver can be used with a hand-held directional antenna (HDA), that is made of a 36″ section of aluminum tubing and has two 30″ cross elements. This is a light, unidirectional yagi that allows the operator to "home in" on signals from a transmitter up to ¼ mile away and to follow the signals to the exact location of the transmitter. This combination of receiver and antenna is indispensable for close inspection of transmitter equipped animals and also for the recovery of transmitters that have fallen off the animal or have been torn off by predators.

The portable receiver can also be used with either the temporary (TDA) or mobile (MDA) directional antennae which mount their yagi on a mast that is rotated by hand. This combination can obtain highly directional signals from transmitters at ground level ½ mile distant. When the transmitters are off the ground 20 feet, directional signals can be obtained at one mile. Either of these antennae can be used to obtain azimuths to transmitters. A transmitter-equipped grouse is located by plotting the intersecting azimuths obtained simultaneously from two or more of these antennae.

The temporary directional antenna (TDA) consists of a 20-foot TV mast (two 10-foot sections) and a horizontally-mounted, 10-foot, 8-element yagi. The main beam of the yagi is a section of ¾ inch thin wall electrical conduit tubing, while the 8 elements are heavy copper or iron wire cut to lengths required to receive signals at the wave length being used. The mast is inserted into a 3-foot length of 1¼ inch heavy wall electrical conduit tubing and over a spindle which permits its rotation through 360 degrees within the conduit. A 10-inch diameter compass rose is bracketed to the top of the 3-foot length of heavy wall conduit; and the direction of the yagi is read on the rose by means of a wire pointer needle brazed to a moveable ring clasp which is fastened to the mast. A guy wire ring located one foot from the top of the mast rests on a ring clasp of slightly larger diameter which prohibits it from slipping down the mast. With this design the mast can be guyed and still rotate within the guy ring. Three guy wires are used in temporary field installations. The RF cable from the yagi is fitted with a coupling to match that on the portable receiver.

The mobile directional antenna (MDA) for use on a vehicle is constructed of a 10-foot section of television mast with a horizontally-mounted yagi of the same construction as in the TDA. The antenna mast is mounted on a spindle which is carried in a Penn Universal TV mast mount that is fastened to a 44 x 34 x ¾-inch plywood platform bolted to car-top carriers. The mast mount, which swivels through 180 degrees, permits the antenna to be lowered or raised quickly. When lowered to the horizontal position for transport the antenna rests on a supporting frame which is affixed to the rear bumper of the vehicle. The yagi is attached to a T bracket which swivels through 180 degrees at the top of the mast. When the yagi is in its horizontal operating position, the T bracket is held in place by a spring-loaded plunger. To place the yagi in position for transport, the plunger is depressed and yagi swiveled to its position parallel to the mast and held there by a spring clasp. The MDA is a mobile reserve unit to meet unexpected changes in the positions of animals whose transmitter signals would normally be reached from the TDA. For studies of animals with large home ranges this unit would be necessary for scouting extensive areas. Specific techniques for using the TDA and MDA to obtain azimuths to a remote transmitter have been developed. The azimuths obtained are plotted on a map and their point of intersection gives the location of the transmitter equipped bird.

Determination of an azimuth to a remote transmitter using the TDA or MDA is based on audio interpretation of the transmitter signal. A hypothetical example will illustrate how azimuths are determined with this equipment. Let us assume that the yagi of our TDA or MDA is pointing due south (180°). There is no audible signal at this point. As the yagi rotates toward the east a barely audible signal is picked up at 165°. This point is called a null point. The yagi continues its eastward sweep and the signal gradually becomes louder until at 100° the levels of loudness no longer can be distinguished. This point is called a maximum. The yagi continues its sweep past the area where loudness levels cannot be separated and enters the northeastern quadrant where the signal strength begins to taper off and at 10° a second null point is reached. The yagi is then swept back to the east until loudness levels indicate a maximum has been reached at 80°. The arc between the maximum points is arithmetically halved to determine the azimuth to the remote transmitter. In this hypothetical case the arc was between 80° and 100°, so the azimuth would be 90°. Because there is variation in audio interpretation of the maximum, 5 azimuth determinations are made and their average provides the azimuth to the transmitter. A skilled operator can carry out the above operation in 4 minutes.

The locations of transmitter equipped grouse determined by azimuth intersects were evaluated by field checks with the HDA. Azimuth intersects made to birds at known map locations (their drumming logs or sight records) showed a mean error of location of 143 feet at distances up to ½ mile. These errors ranged from 26 to 298 feet with 81 percent of them falling into a bracket of 26-198 feet. Errors decreased as the distance from the transmitter to the receiving equipment decreased.

Another attribute of this system which soon became evident was that, as a result of the flexible antenna which whipped as the birds moved, the pitch of the audio signal varied. We found, by direct field observations, that a steady signal indicated the bird was at rest; a slowly pulsing signal showed walking; a short series of sharp pulses flying; an erratic combination of sharp and slow signal pulses indicated feeding in trees; and an accelerated rhythmic series of pulses was very characteristic of drumming activity.

Cost of System—Approximate cost of the system as described can be summarized as follows: 6 transmitters @ $60.00, $360.00; control-center (non-portable receiver, etc.) $1,000.00; portable receiver $450.00; 5 antennae @ $25.00, $125.00; Citizens Band communications system (2 walkie talkies, 1 transceiver) $450.00 for a total of $2,385.00. This cost could be reduced by using a second portable receiver instead of the non-portable communications equipment in the trailer. It is necessary to have at least two field biologists to operate the system in the field and, in present stages of development, the services of an electronics engineer for consultation and adjustment of equipment are mandatory.

FIELD STUDIES

The equipment and the technique described were used in a study of male ruffed grouse occupying adjacent activity centers during the 1962 breeding season. An area occupied by 7 males and having access from a central roadway was selected for the study. The non-portable receiving system served as the control center in the middle of the area so that signals from all transmitter-equipped birds could be obtained. A network of five TDA was arranged around the control center so that azimuths from this latter point could be intersected with azimuths from one or more TDA locations to enable us to plot the locations of the birds. Two men operated the system.

Six males were trapped and taken into the laboratory where they were equipped with transmitters. Each transmitter was checked for operation before the birds were released near their trap sites. The location of these birds was begun immediately by plotting pairs of azimuths obtained from the control center and surrounding TDA.

The operator of the control center coordinated this procedure by first determining the general direction to a transmitter. He then made a choice of the TDA which was (1) closest to the bird, and (2) provided an angle of intersection from 40°-100°. The operator of the portable equipment was directed to this TDA; and azimuths were obtained as specified by the control center operator. The azimuths were reported to the control center from the TDA site and were plotted with matching azimuths obtained by the control operator. The position of a grouse could be obtained in approximately ten minutes and, as each position was determined, the location, date, time and appropriate environmental data was punched on a 3 x 5 needle sort card for later analysis.

On numerous occasions when azimuth plots indicated that males were drawing near each other, the control operator would notify the portable equipment operator, informing him as to the location of each bird and the best way to approach without disturbance. This permitted a human observer to be present when it appeared that an interesting event was to occur between birds.

A total of 479 records of location and activity was obtained on three of the RF marked grouse for 28, 29 and 32 days, respectively. Transmitter malfunction, trap injury and improper harness fit pre-

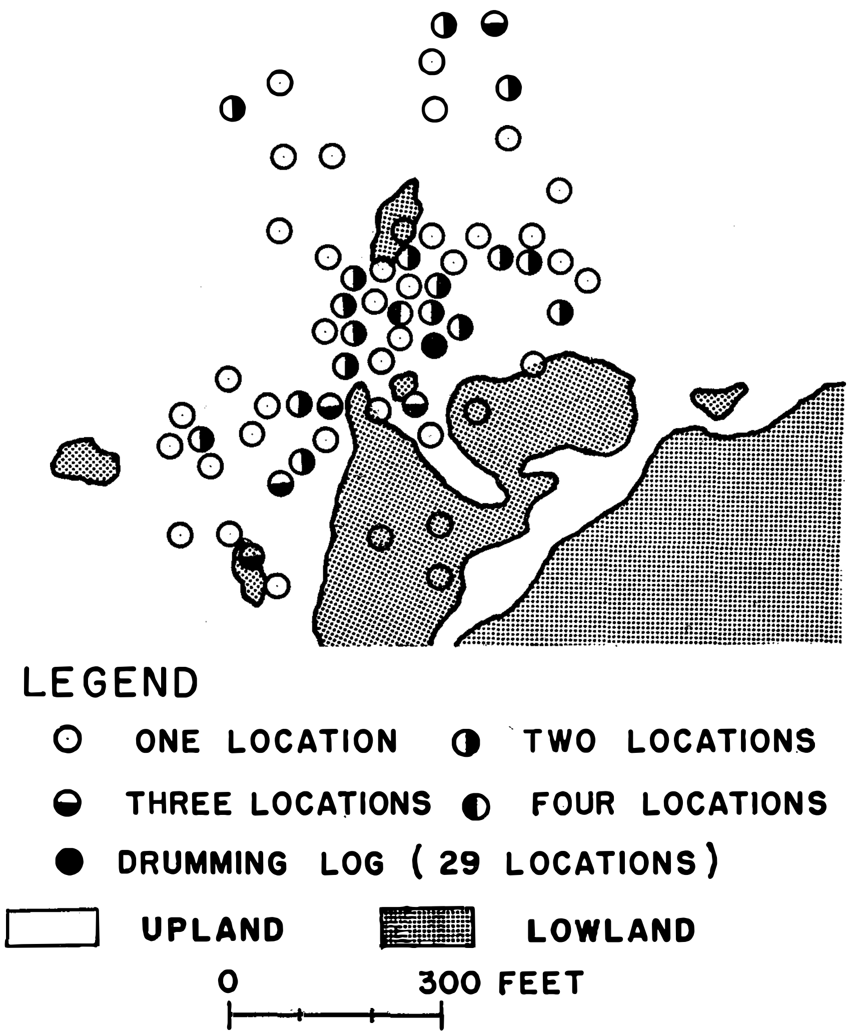

Fig. 3. Map showing 135 locations obtained on one male ruffed grouse over a 28-day period.

vented the remaining three from contributing records over a significant period of time. Some examples of the data obtained during this study follow.

Tracking the movements of these birds developed a picture of their home range and the value of certain habitat features as shown by the frequency with which the bird used them. The results of tracking one grouse for 28 days (Fig. 3) shows one range configuration in relation to frequency of use and upland-lowland habitat borders.

As indicated earlier, the activity of RF marked birds can be determined by listening for certain variations in the signal sound of their transmitters. A sequence of signal sound interpretation as obtained at a receiving station ¼ mile distant, which follows, reports the activity of two males using adjacent activity centers and illusrates the kind of information that can be secured for basic behavior and energy studies.

The activity sequence begins at 12 noon on May 10, 1963. Both grouse are ¼ mile distant. Grouse A, a juvenile male, is walking slowly some distance from his drumming log while grouse B, an adult male, is drumming at his log.

At 12:24 p. m., grouse A takes to the air in a short flight toward his drumming log, lands, and walks for 3 minutes to his log and at 12:35 p.m. begins to drum. Meanwhile, grouse B has been drumming at 4-5 minute intervals. Both birds drum regularly and sometimes begin their drums within ½ minute of each other. At 3:30 p.m., other duties of the listener interupt the activity sequence.

Returning to the listening post at 5:15 p.m. it was noted that grouse B was drumming and continuted to drum until 6:36 p.m. while grouse A was alternately walking and motionless from 5:30 to 7:28 p. m. The length of the periods of walking varied from 1-20 minutes and the length of the periods of no motion varied from 5-14 minutes.

At 7:35 p.m. both A and B flew short distances. The change in signal strength and accompanying signal sound variations indicated that B had flown to a tree and was feeding. Grouse A landed on the ground, remained motionless for 2 minutes, and then flew to a tree and also began to feed. Grouse B fed from 7:37 p.m. to 7:52 p.m. and then flew to the ground, walked for 2 minutes and then became motionless, indicating that he had selected a ground roost position for the night. Grouse A fed from 7:41 to 7:55 p.m. and then flew to the ground, walked for about 3 minutes, and at 7:59 flew to a tree and bcame motionless. His night's roost was in a tree.

POTENTIALS OF THE SYSTEM

Although the objectives of this study were limited to development of a remote radio-tracking system for ruffed grouse many other potentials for ecological work are evident at this stage.

Location of individual animals without direct disturbance by the observer is a self-evident use for movement and home range

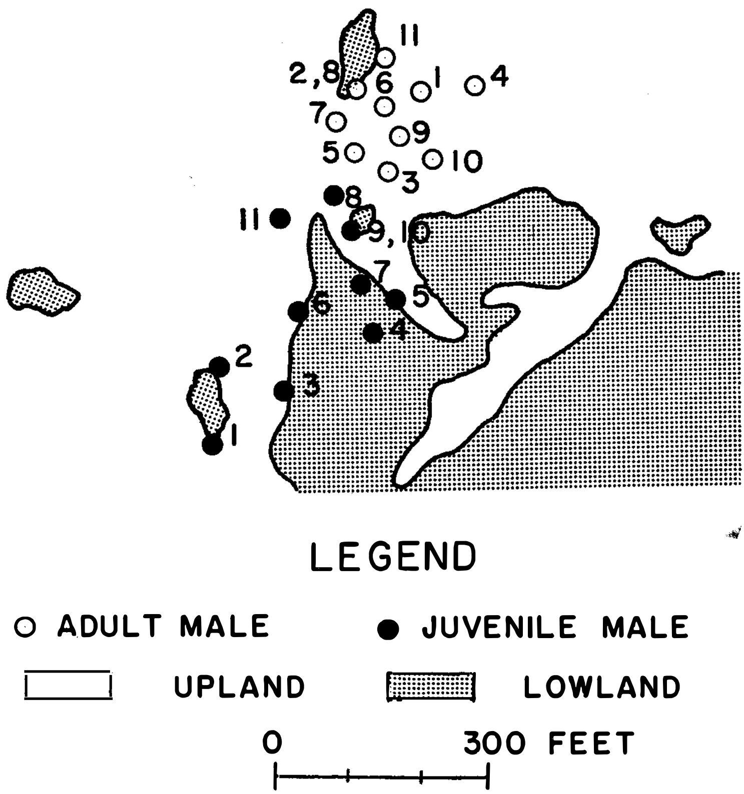

Fig. 4. Map showing 11 simultaneous locations on two male ruffed grouse over a 12-hour period. Their respective drumming logs are at location 3.

studies. As the accuracy increases with improved equipment and skills, close interpretation of reactions to weather, changing food supplies, cover conditions, and other similar phases of the ecology of an animal will be possible. These can, of course, be analysed by sex and age and should be of particular value in habitat improvement evaluations.

The time-space relations of two or more RF marked birds using adjacent activity centers will provide data on intra-specific relationships. A one-day sequence of the positions of a pair of male grouse during their breeding season is shown in Figure 4.

Patterns of the movement of individuals can be recorded in detail along with certain behavior characteristics. We are planning the 1963 operation to obtain data on grouse mating and nesting activities.

The predation that occurred on four RF marked birds during March 1962 indicated the value of the transmitters in studies of predator-prey relations. In each case the transmitter continued to function after the bird was killed and in three cases the cause and type of predation was determined. Had these birds only been banded their fate would have been unknown.

Uses in studies on effects of disease or pesticides on individual animals were demonstrated by one male which had damaged his eyes in the trap. Although he was in poor condition we placed a transmitter on him. This bird lived for 17 days in an area of dense ground cover. Using the HDA an operator could find him in 15 minutes even though he was well hidden and only moved when stepped over. Here then is an electronic ''bird dog'' for studying the fate and reactions of a sick animal. An experimental approach by inoculation of healthy animals with disease organisms can be visualized.

Persons acquainted with field census methods realize that we do not always know the reactions of animals to an observer moving through the habitat. We plan to run King census lines in an area containing transmitter equipped birds to obtain data on this vital question.

ACKNOWLEDGMENTS

Throughout this study Mr. Gordon Gullion has provided much technical assistance in planning and field work. Mr. Sidney Markusen, Electronics Engineer, Cloquet, Minnesota, developed and constructed all equipment used since the first phase of the study. John Weigand served as field assistant and Dr. Bruce Brown, Superintendent, Cloquet Forest Research Center, made laboratory facilities available. The work has been conducted under terms of National Science Foundation Grants GS-8644 and G-1785 and in cooperation with the Minnesota Division of Game and Fish.

SUMMARY

The development of a system for radio-telemetry studies of the ruffed grouse describing the equipment, the techniques, and some results obtained is presented. The cost of this system and the potentials for further studies are discussed briefly.

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DISCUSSION

MR. ANDREW RADVANYI: You mentioned the point that the positioning of a transmitter did not interfere with the walking or flying behavior of the bird. I should like to know to what extent this might influence or interfere with the nesting habits of these birds?

DR. MARSHALL: Obviously this harness would play a detrimental part on a nesting bird, but this technique is still evolving very rapidly. We are this spring using a slightly different harness. We have placed the battery on the back and the transmitter well up on the upper breast of the bird. This seems to be successful and I do not think it will interfere with nesting.

The techniques of mounting are going to vary with the purpose of the study and with the animals used and so on. This is going to have to depend on the skill of the field biologist.

DR. KEN HODGSON [Maine]: I would just like to ask if you have been able to use these radio transmitters on birds in the winter and, if so, what effect would it have on the bird?

DR. MARSHALL: We have not. The experiments were designed and set up for the male bird during the drumming season. I can assure you that the technicians were busy for more than four months getting this set up and we ran out of gas. We were going to work with 12 transmitters to look into the question of hens and males during the breeding season. I hope next year we can get at the problem of winter movements and activity. I don't think this is a big difficulty.

MR. R. G. BAKER [Michigan]: Bill, have you done any work at all with the problem of how you could cut off the battery when you are not using the transmitter? I was wondering if you were working at all on the possibility of somehow or another to turning on and off the transmitter on the bird so that your battery would be longer lived?

DR. MARSHALL: We have not. I understand that the power requirements for such a procedure would be very considerable. It would involve quite an expensive bit of machinery and also a pretty good power supply. This thing is set up so we can use it away from a source of power.

MR. HARVEY FINLEY [Colorado]: We kept a number of grouse for insecticide studies and in handling these birds we have had great success, but we have had a few losses, apparently from shock. I wonder whether you had any losses of grouse due to handling of them?

DR. MARSHALL: Well, we have handled something on the order of 900 grouse since 1956, and have not recorded such losses.

SAMPLING PROCEDURES AND ESTIMATES OF YEAR-ROUND RECREATION USE ON 100 SQUARE MILES OF THE GEORGE WASHINGTON NATIONAL FOREST[1]

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It is predicted that the population of the United States will reach 350 million by the year 2000. At the same time disposable consumer income is expected to climb from $354 to $1,370 billion, and the average workweek probably will drop from 39 to 32 hours. In addition, the number of passenger cars is expected to double long before the year 2000. These changes (increasing population, income, leisure, and mobility) are expected to exert tremendous additional pressure on outdoor recreation resources, causing Federal, State, and private land management agencies to devote increasing attention to demands for forest recreation. Because of these growing pressures on outdoor recreation facilities and forest land there is a critical need for reliable estimates of use. Land managers need to know how many people use the forest, for how long, and for what purposes. Meager or inaccurate information can lead to unwise planning, poor distribution of funds, and frequently less than full desirable use.

Some success has been realized in measuring ''mass types'' of recreation use usually associated with developed sites (Marcus, *et al.*, 1961). But dispersed types of recreation use such as hunting, fishing, primitive camping, and hiking, which comprise an extremely important segment of outdoor recreation in forests and other wild lands, have received far less attention. Work is needed to describe populations and provide accurate, low-cost estimates of current recreation use. Consequently, a sampling plan and procedures for conducting a pilot-test study were formulated; this paper reports the techniques and results.

In his problem analysis of forest recreation research, Dana (1957)

[1]This investigation was conducted as a Master of Science graduate program under contract from the U. S. Forest Service to the Virginia Agricultural Experiment Station and was carried out by the Virginia Cooperative Wildlife Research Unit (Virginia Polytechnic Institute, Virginia Commission of Game and Inland Fisheries, The Wildlife Management Institute, and U. S. Fish and Wildlife Service cooperating) which is administratively attached to the Department of Forestry and Wildlife, Virginia Polytechnic Institute.

underscored the need for research to improve planning, development, rehabilitation, and management of outdoor recreation facilities and areas. Basic to improved management is a knowledge of current recreation conditions, but information concerning methods of sampling recreation use on large units of land is meager. Marcus, *et al.*, (1961) discuss methods of measuring recreation use on National Forests, but their discussions centered largely on developed sites. Overton and Finkner[2] describe sampling procedures to obtain estimates of hunting pressure on game management areas in Florida. Their work, involving entrance or exit sampling, using roadblocks, provided important information used in our study. Robson (1960) developed hypotheses and population concepts to obtain samples and unbiased estimates of fishing pressure and catch, using a stratified random sampling approach. Robson's paper also provided considerations useful in planning our work. Hutchins and Trecker (1961) conducted a study of recreation use in Wisconsin State Parks. Although they did not employ procedures for estimating errors, some of their concepts and findings provided valuable background considerations.

A central problem in the present effort was defining the population and limiting the attributes to measure. We made an initial assumption that estimates of recreation must be tied to large areas of forest land, generally under a single policy of management either by ownership or coordination—such as a National Forest Ranger District. Accordingly, we elected to describe large units of forest land in terms of space and time strata. It was assumed that if it were possible to block all exits (roads, trails, waterways, etc.) 24 hours a day for any specified period and if we could learn from all departing persons the amount and type of use they had made of the area (since their last entry), then, at the end of the specified time we would have a complete census of use. This census would be valid if each individual had supplied accurate information and if everyone had left the area at the end of the specified period. Of course, this type of total census is so difficult and expensive that it is impossible. However, the concept gives us a basis for sampling. Further, if we assume that we can devise intelligent classifications for all time and space combination by blocking exits and soliciting use information, we have provided a definable population of use by people leaving the area. This, then, lends itself to stratified random sampling. In terms of universal situations, time can be divided into meaningful

[2]Overton, W. S. and A. L. Finkner. 1960. The sample roadblock method of estimating hunting pressure. Presented at the joint meeting of Biometric Society, American Statistical Association and Institute of Mathematical Statistics. August 23-26, 1960, Stanford, California. (Mimeographed).

seasons, periods of weeks, days, and hours of the day. In addition, all possible exits (in space) by classes or strata can be recognized.

Accordingly, we selected a study area containing approximately 100 square miles in the George Washington National Forest, which offered an excellent variety of outdoor recreational opportunities. The area is favorably located in relation to several large metropolitan areas, and can be reached by a good system of highways from several directions, thus assuring moderate-to-heavy recreational use. Located in Pendleton County, West Virginia, and Rockingham, Highland, and Augusta Counties of Virginia, the area contained approximately 30 miles of heavily-stocked trout water; and virtually all of the 100 square miles support good populations of deer, bear, turkey, grouse, and squirrels. Hunting and fishing access is good, with 45 miles of all-weather Forest Service roads, 10 miles of State-maintained paved roads, 25 miles of hunter-access jeep roads, and 90 miles of trails. The area contains five Forest Service developed sites, all with camping and picnicking facilities, and one natural area with an elaborate trail shelter. There is a large Girl Scout Camp within the boundary, and numerous private camps used year-round.

All exits from the area were sorted into five classes: A, paved roads; B, unpaved roads; C, foot trails and gated access roads; D, seasonal access roads for hunting; and E, hunting access roads open year-round. Although not employed here, traffic counters would have been useful in stratifying exits.

In making this pilot test, we selected one calendar year for sampling (June 17, 1961-June 17, 1962). Seasonal stratifications were made on the basis of three levels of expected use: High—big game hunting and opening of fishing season; medium—summer vacation season, small game hunting and fall color periods; low—period between the close of hunting and opening of fishing season. Also, differences between weekends and holidays and weekdays were anticipated; and differences between day and night were also recognized and stratified accordingly.

Because of anticipated differences in the number of parties leaving per unit of time by type of exit (stratum), the length of time of the sampling unit was adjusted inversely to the expected flow of traffic. Thus, on exit class A (paved roads), a one-hour sampling unit was used; on class B (unpaved roads), a two-hour sampling unit; and on classes C, D, and E exits (foot trails, gated roads, and jeep access roads), a four-hour sampling unit was established. These sampling intervals were established without knowledge of optimum length of sampling unit.

The allocation of sampling effort to individual strata was arbitrarily chosen because estimates of variation were not available from previous work, and no presample data were taken. A total of 648 sampling periods was selected and distributed as follows: during the high use period (opening weeks of big game hunting and fishing seasons) 11 per cent of the samples were taken; the medium use period (summer recreation season, all hunting and fishing seasons except opening weeks) was assigned 82 per cent; and the low use period (winter months of February and March) had 7 per cent. Sampling effort within each use period was allocated equally to weekend plus holiday and weekday strata for all exit classes. In addition, 10 per cent of the day sample in each stratum was allocated to night sampling. A total of 157,680 hours was available for sampling (total census requirement); of this, 1,472 hours were actually sampled using 648 sampling units. Thus, we actually sampled 0.93 per cent of all sampling opportunity. A summary of the allocation of sampling effort in this study for the one-year sample period is shown in Table 1.

A questionnaire completed by a trained interviewer was used to obtain information from parties leaving the area. The questionnaire was completed from information supplied by the head or member

TABLE 1. ALLOCATION OF SAMPLING UNITS[1] IN PERCENTAGES FOR ALL STRATA USED IN THE DISPERSED RECREATION SAMPLING STUDY, NORTH RIVER AREA, GEORGE WASHINGTON NATIONAL FOREST, VIRGINIA

			Season			
		Exit class[1]	High	Medium	Low	Total
Weekends Holidays	Day	A	1.5	12.0	1.5	15.0
		B	1.5	12.0	1.5	15.0
		C, D, E	1.5	12.0	0.0	13.5
	Night	A	0.3	1.6	0.4	2.3
		B	0.3	1.6	0.4	2.3
		C, D, E	0.3	1.6	0.0	1.9
Weekdays	Day	A	1.5	12.0	1.5	15.0
		B	1.5	12.0	1.5	15.0
		C, D, E	1.5	12.0	0.0	13.5
	Night	A	0.3	1.6	0.4	2.3
		B	0.3	1.6	0.4	2.3
		C, D, E	0.3	1.6	0.0	1.9
TOTALS			10.8	81.6	7.6	100.0

[1]Class A—sampling unit, one hour; class B—sampling unit, two hours; classes C, D, and E—sampling unit, four hours.

of each household represented in all parties. Roadblocks were set up in the best locations (from a safety standpoint) to halt traffic leaving the study area. Warning equipment used during the day consisted of a series of portable traffic signs and caution blinker lights erected on both sides of the roadblock. For night samples, roadblocks were illuminated by flood lights powered by a portable generator. Prior to sampling, all locations and equipment were checked and cleared by local authorities including the Virginia Highway Commission, County law enforcement authorities, and the Virginia State Police.

The questionnaire was designed to obtain information concerning the number of man-hours and type of use made of the study area since the last entry. If the purpose of the visit had been for recreation, then use was divided into three major categories: private camps, developed recreation sites (camping and picnic), and undeveloped forest areas. Undeveloped area use was subdivided into eight component uses which included hunting and fishing. Game species hunted, the type of weapon used, and fishing use by species were also recorded. Weather, mode of travel, party size, and number of previous visits to the area were also noted on the questionnaire.

To assure maximum cooperation from local folks, information sheets were posted in places of business around the study area. News releases giving the objectives and methods of the study were run in local papers. In addition, all parties interviewed were given mimeographed sheets explaining why they had been stopped, together with assurance that all information given the interviewer was strictly confidential and was without name identity.[3]

RESULTS

Approximately 2,000 man-hours were spent collecting field data. As already noted, 1,472 hours were spent manning the 648 roadblock samples; the remaining 528 hours were spent in travel.

One thousand five hundred and thirty two households were interviewed and a questionnaire completed on each. Data from these questionnaires were used to generate a total recreation use estimate of 691,837 man-hours $\pm$ 18 per cent.[4] Estimates of recreation use for private camps, developed sites, and undeveloped areas were: 233,711; 182,389; and 275,688 man-hours, respectively, with errors of 26, 28, and 21 per cent. Hunting, sightseeing, fishing, and primitive camping were the major uses of undeveloped areas;

[3]Copy of approved questionnaire (Budget Bureau No. 40-6128) is available from the Southeastern Station.
[4]All errors are at the 67-per cent confidence level.

TABLE 2. TOTAL ESTIMATES AND ERRORS FOR USES SAMPLED IN THE NORTH RIVER AREA OF THE GEORGE WASHINGTON NATIONAL FOREST, FROM JUNE 17, 1961, TO JUNE 17, 1962

Type of use	Man-hours	Per cent error at 67-per cent confidence level
COMMERCIAL	56,960	24
RESIDENTIAL	71,073	37
OTHER	13,438	16
RECREATION	691,837	18
Permanent camps	233,711	26
Developed area	182,389	28
camping	144,329	31
picnicking	38,058	60
Undeveloped area	275,688	21
picnicking	4,334	43
nature study	14,873	98
swimming	1,508	45
fishing	34,119	26
hunting	140,517	34
hiking	1,630	63
camping	24,285	47
sightseeing	54,395	30
TOTALS	833,314[1]	15

[1]Total not corrected for rounding errors due to desk calculator limitations.

TABLE 3. OPTIMUM ALLOCATION OF SAMPLING EFFORT, IN PERCENTAGES OF TOTAL SAMPLES TAKEN FOR ONE YEAR IN NORTH RIVER

		Exit class	Season High	Season Medium	Season Low	Total
Weekends Holidays	Day	A	4	25	1	30
		B	17	11	0	28
		C, D, E	0	0	0	0
	Night	A	0	0	0	0
		B	0	0	0	0
		C, D, E	0	0	0	0
Weekdays	Day	A	10	17	0	27
		B	3	12	0	15
		C, D, E	0	0	0	0
	Night	A	0	0	0	0
		B	0	0	0	0
		C, D, E	0	0	0	0
TOTALS			34	65	1	100

hunting was estimated at 140,517 man-hours; sightseeing, 54,395; fishing, 34,119; and camping, 24,285. Totals, additional component uses, and associated errors are shown in Table 2.

To determine the efficiency of our sampling methods, optimum allocation of effort was determined (Table 3). Using optimum allocation, we could have obtained estimates of total recreation use with approximately the same per cent of error, with a total of 440

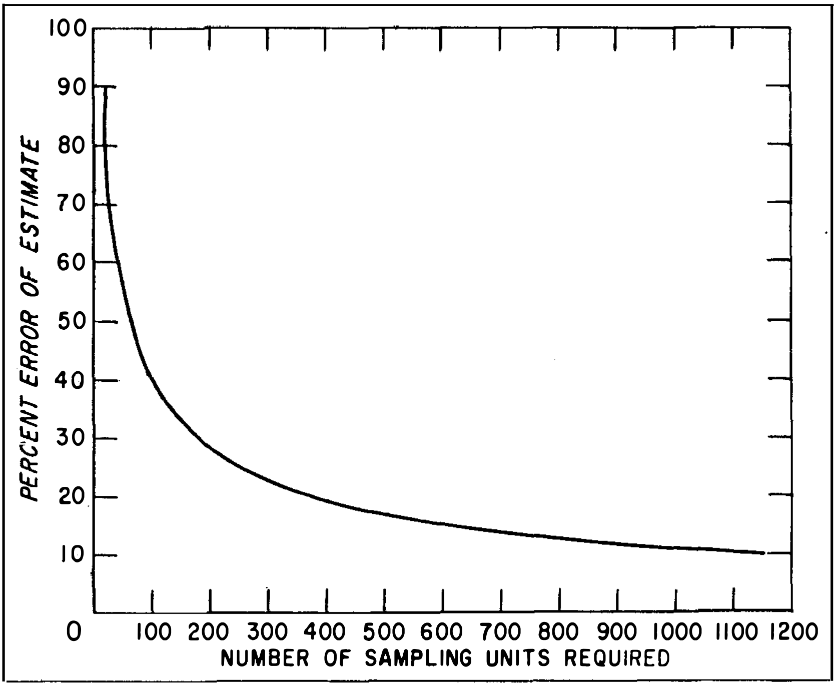

Figure 1. Relationship between number of samples and error of total estimated recreation use based on North River samplings.

sampling periods (as compared to the 648 taken). If we were willing to accept an estimate with a 25-per cent error, we could have reduced the total sampling effort to 240 (Fig. 1). Optimum allocation of sampling effort also showed that sampling was not prudent on exit classes C, D, and E (foot and jeep trails) night or day. On the roads (classes A and B) day sampling was vastly more efficient than night sampling.

DISCUSSION

The ORRRC report (Anon., 1962) ranked recreation activity of persons 12 years and older from June 1, 1960, to May 30, 1961. Driving and walking for pleasure lead all other types of uses by a considerable margin. Camping and hunting appear further down the list, while swimming, sightseeing, and fishing were in the top 10 activities pursued by Americans during the study period. In the North River case history it was evident that use of undeveloped forest areas (mainly hunting, sightseeing, and fishing) was very important. Private camps were the second major contributors to use, while developed sites, mainly camp grounds, provided an important source of recreation. This simply shows that generalized data do not apply to local areas, and that planning must be closely tied to a knowledge of area use and the type of recreation resources available.

Most importantly, results from this case-history study have shown that by using the stratified random sampling plan, and with no knowledge of how to optimize sampling effort, acceptable estimates of total and component recreation use can be obtained.

One question will probably be: Can this sampling plan be used on *any* area to obtain recreation use estimates and errors? In all probability no, since this plan was designed for a specific study area. However, the basic principles employed in this study are thought to have universal application. The time stratifications, including the weekend-holiday and weekday, and the day and night strata, seem to be quite reasonable. In fact, this portion of the sampling plan probably can be used as a universal approach. Characteristics of exits, on the other hand, and seasons will vary with local conditions and will affect sample size and allocations needed to obtain estimates at desired levels of accuracy. Generally, the cost of a study of this type will depend upon: (a) size of the area selected, (b) duration of the study, and (c) the level of accuracy required or desired.

This sampling plan, together with the procedures described, is now being tested on the Ocala National Forest in Florida. Information gained from this test will yield improved planning-factor data and stratification information to fit universal situations and provide land managers with accurate, low-cost estimates of recreation use.

SUMMARY

Results from a one-year, case-history sampling study of recreation use on a 100-square-mile unit of the George Washington National Forest indicated that, with no knowledge of optimum allocation of sampling effort, estimates of total use could be accurately made. Component uses in most cases were also predicted with low errors. Accuracy of estimates depends on selection of strata and efficient allocation of sampling effort.

In this study a total of 700,000 man-hours of recreation use (importantly including hunting and fishing) was examined in the light of area resources and recreation opportunities. Although the distribution of uses differed considerably from nationwide data reported by ORRRC, use was clearly related to forest resources and recreation opportunity in the area.

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THE HIGH BIOMASS OF WILD UNGULATES ON EAST AFRICAN SAVANNA

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The savanna lands of East and Central Africa support an unusually high biomass of wild ungulates. Various reasons have been postulated for this high biomass, but until very recently there were few quantitative data applying to either the biomass or the factors affecting it. In 1962 we completed a field study of the ecology of plainsland and plains wildlife in East Africa. This paper presents some of the results of our study which define and explain this biomass.

The project has involved three visits to East Africa from 1956 to 1962, plus additional research in Africa, Asia, Europe, and North America that applied to plainsland ecology. The major period of field research in the study area in East Africa covered 30 months from 1959 through 1961. It was initiated under the Foreign Field Research Program of the National Academy of Sciences-National Research Council, and was subsequently extended by the New York Zoological Society, the Government of Kenya, Rockefeller Foundation, and the Academy. We are deeply indebted to the many individuals and organizations in East Africa with whom we had the privilege of working and whose friendly and generous cooperation, help, and hospitality made this work possible.

STUDY AREA

The study area, the Serengeti-Mara Plains Region, covers over 10,000 square miles of flat and rolling land astride the Kenya-Tanganyika border, immediately east of Lake Victoria. Isolated by both topography and politics, this region has remained largely unaffected by cultural and political changes which in the past century have altered the African landscape and destroyed or much modified the formerly abundant plainsland-plains wildlife situations. Well over a million head of ungulates representing nearly 30 different species are found in the study area, along with eight species of larger predators. Some animals are resident yearlong in the bush, while during the irregular biannual rainy seasons the migratory animals graze on the open grasslands which make up about one third of the study area. When these grasslands dry, the animals move into the surrounding bush country where they are constantly on the move following water and food until rainfall brings them back to the open plains.

METHODS

There were almost no data available on the wildlife or the ecology of the area when we initiated the study; we even had to make our own maps. To obtain a continual and representative sample we developed a strip transect method, somewhat similar to the King strip census (Leopold, 1933) or variable strip methods (Worthington, 1954). Most animals in the study area do not fear vehicles, so disturbance off the strip and flushing angles and distances were not problems (Davis, 1960). Visibility was usually good and the numbers of animals involved was great, so it was neither practical nor necessary to measure the distance from the observer to each animal (Dasmann and Mossman, 1962). Instead, we observed a strip centered on the vehicle and extending a predetermined distance on each side. All animals on the strip were recorded by standardized abbreviations on a form, along with age, sex, and observations on associations, behavior, movements, and notes on weather, fire, stages of growth of vegetation, availability of water, and time of day. The travel routes were chosen to provide the widest possible coverage of the study area. Roughly 2,000 miles a month were driven, usually cross country since virtually no roads existed in the area. We used small aircraft for additional observations and total counts. After establishing a technique for sex and age-class determinations from the air we got spot population samples from the whole area to check against ground strips. We also flew strip transects working out population densities for better comparisons between areas (Cronemiller and Fisher, 1946).

With the Kenya Game Department, Wilken Air Services of Nairobi, and the Tanganyika National Parks, we made one complete aerial census of the entire study area, using light aircraft with pilot and two enumerators, D. R. M. Steward of the Kenya Game Department and L. M. Talbot. The area was divided into very small counting units, usually one to five miles in length. These were counted in turn with the aircraft flying between 400 and 700 feet elevation. Each enumerator counted a strip 150 to 400 yards on either side of the aircraft. Herds too large to count visually were photographed using high-speed color film in a 35mm. camera with 50mm. lens. Daily reconnaissance flights were made to define counting areas and note animal movements. As an exercise in photo-interpretation, a Royal Air Force photo-reconnaissance Canberra aircraft photographed the major concentration of wildebeests at the start of our light aircraft census. The films were sent to London, photomosaics made, and 194,411 wildebeests counted. Our count of the same animals was 194,000 to 197,000—.02 per cent below, or 1.3 per cent above the R.A.F. numbers. The apparent accuracy indicated by this double count is particularly gratifying because the animals involved, being concentrated and in difficult terrain, were by far the most difficult wildebeests to count in the whole area. We would, therefore, expect to find our maximum error here.

To facilitate studies of movements, behavior, and food habits we captured, marked, and released a series of plains animals. We used field immobilization techniques, detailed elsewhere (Talbot, 1960; Talbot and Lamprey, 1961; Talbot and Talbot, 1962b), to capture individuals of 15 species of plains wildlife. Marking was by means of metal or plastic ear tags, colored plastic ear strips, painted horns, and docked hair. The capture work was very successful and the marked animals provided invaluable data.

RESULTS

Biomass

To calculate biomass we determined the numbers of animals and their age and sex ratios as outlined above. Weights were determined largely from animals we weighed ourselves, since few previous weight records were available. We weighed animals that we captured or killed, using certified scales and a collapsible derrick on the back of our Land-Rover (Talbot and Talbot, 1962a). In this manner we obtained a series of weight records from most species in the area. Additional weights of wild and domestic animals from the study area were obtained from our cooperators. The resultant weight records enabled us to establish average figures for males, females, and various age groups in the populations, and to use these specific weights—instead of arbitrary averages—to determine biomass.

Table 1 presents yearlong biomass data for the study area. The

TABLE 1. YEARLONG STANDING CROPS OF DOMESTIC LIVESTOCK AND WILD UNGULATES IN THE SERENGETI-MARA STUDY AREA

Type of range	Approximate area square miles	Animals	Approximate yearlong standing crop pounds per square mile
Grassland, bush, and mixed[1]	10,700	12 wild ungulates[2] 4 domestic ungulates[3]	30,200[2]
Bush	7,500	12 wild ungulates[2] 4 domestic ungulates[3]	23,300[2]
Open grassland	3,150	6 wild ungulates[2] 4 domestic ungulates[3]	46,800[2]
Mixed grassland and bush[4]	1,000-2,000	12 wild ungulates[2]	70,000-100,000[2]
Bush[4]	2,000-3,000	12 wild ungulates[2]	30,000[2]

[1]Entire wildlife habitat within study area.
[2]Fifteen additional species of ungulates are present in the area, but they are either smaller or rarer than the 12 included and their numbers are not known, so their biomass is not included. Therefore the biomass figures as given are low.
[3]Cattle, sheep, goats, and donkeys grazed by the Masai tribes.
[4]Ungrazed by domestic livestock, generally within about five miles of water.

wildlife habitat within the study area covered about 10,660 square miles. Of this, about 3,144 square miles were open grassland and 7,515 square miles were bush. There is a relatively low population of animals resident in the bush country, including elephants [*Loxodonta a. africana* (Blumenbach)],[1] buffaloes [*Syncerus c. caffer* (Sparman)], impalas [*Aepyceros melampus suara* (Matschie)], waterbucks [*Kobus defassa adolfi-friderici* (Matschie)], giraffes [*Giraffa camelopardalis tippelskirchi* (Matschie)], rhinos [*Diceros bicornis* (Linnaeus)], and some topis [*Damaliscus lunatus jimela* (Matschie)], and kongonis [*Alcelaphus buselaphus cokii* (Günther)], The yearlong biomass from these animals is about 3,008 pounds per square mile.

Most of the wild animals are migratory, and these include Thomson's gazelles [*Gazella thomsonii biedermanni* (Knottnerus-Meyer)], wildebeests [*Gorgon taurinus hecki* (Neumann)], zebras [*Equus burchelli böhmi* (Matschie)], elands [*Taurotragus oryx pattersonianus* (Lydekker)], and some topis and kongonis. These animals spend the wet seasons on the open grasslands and the dry seasons in the bush. Domestic livestock—Masai cattle, goats, sheep, and donkeys—also graze the open plains during the wet seasons. Some of them follow the wildlife into the bush country during the dry seasons, and some leave the region, being moved to grazing lands in the adjacent highlands. For roughly six months each year the open grasslands support a biomass of about 93,545 pounds per square mile, and for the remaining six months they are virtually empty of ungulates. The yearlong average biomass, then, is about 46,773 pounds per square mile.

[1]Nomenclature follows Swynnerton and Hayman (1950).

During the six months of dry season the bush country supports a biomass of 37,549 pounds per square mile, made up of the migratory animals plus the few resident ones. The average yearlong biomass in the bush country is about 23,299 pounds per square mile.

The overall average yearlong biomass, i.e. the weights of the average wildlife and domestic livestock populations divided by the square miles of the area, has been about 30,214 pounds per square mile[2] of which 80.2 per cent is wildlife and 19.8 per cent domestic livestock.[3]

These overall figures, however, do not necessarily reflect the true carrying capacity of the landscape. Much of the area provides virtually no food for the ungulates and serves largely for transit, travel routes. Other areas, especially those within about five miles of reliable water supplies and those not grazed by domestic livestock, support extremely high yearlong biomasses. In the relatively well watered savanna country between the vast open grasslands and the true bush, the yearlong ungulate biomass ranges from around 70,000 to 100,000 pounds per square mile, and even in the bush country, within about five miles of water the yearlong average is well over 30,000 pounds per square mile. There is no evidence of overgrazing with these stocking rates.

The average biomass obtained from cattle, goats and sheep under native herding is about 11,000 to 16,000 pounds per square mile in the equivalent savanna, and 2,000 to 8,000 pounds per square mile in the bush. Under this grazing intensity the habitat shows moderate to severe overgrazing.

An even more striking comparison can be made with European cattle ranches in equivalent high savanna. In these areas, with careful management including fencing and provision of water points, the average biomass is 21,000 to 32,000 pounds per square mile (Ledger, *et al.*, 1961), a third to a fifth of that obtained by unmanaged wild ungulates. Even in these ranch areas evidence of overuse is the rule.

Table 2 compares biomass figures from the study area with those from wild and managed populations in other parts of the world. It is not a complete review; only a few representative examples have been chosen. Except where otherwise noted, weights are based on data provided by the references involved.

The biomass of 30,000 to 100,000 pounds of wild ungulates in the study area is high by any standards. To assess the factors contrib-

[2]These figures confirm the estimate made by Petrides (1956) of an average biomass of 25,000 to 30,000 pounds per square mile in this type of habitat.

[3]These figures refer to conditions up to about 1960, when livestock was removed from part of the area in Tanganyika through changes in regulations affecting grazing.

TABLE 2. YEARLONG UNGULATE BIOMASS DATA FROM EAST AFRICAN STUDY AREA AND ELSEWHERE

Approximate yearlong biomass pounds per square mile	Approximate size of area square miles	Animals	Range Type	Location	Reference
70,000-100,000	1,000-2,000	Wild ungulates	Savanna	East Africa	This study
30,000	2,000-3,000	Wild ungulates	Bush	East Africa	This study
21,300-32,000[1]	....	Cattle	Managed savanna (European ranches)	East Africa	Henderson, 1950; Ledger, et al, 1961
26,700[1]	....	Domestic livestock	Average of virgin long & short grass	Western U. S.	Watts, et al., 1936
14,000-20,000	....	Bison & associated wild ungulates	Prairie	U. S.	Bourlière, 1961; Petrides, 1956
19,700[1]	1,126,500	Domestic livestock	Average of all virgin ranges	Western U. S.	Watts et al., 1936
11,200-16,000	....	Domestic livestock	Savanna (tribal grazing land)	East Africa	This study
10,600	....	Black-tailed deer	Managed chaparral	California	Taber and Dasmann, 1958
6,900	....	Black-tailed deer	Average of oak woodland plus chaparral	Pacific Coast North America	Taber, 1961
5,800	2	White-tailed deer	Woodland proper density	Michigan	O'Roke & Hamerstrom, 1948
3,550	4,373	Red deer	Deer Forest	Scotland	Lowe,1961
1,360	88,080	Mule deer (5 races)	Average all ranges	California	Longhurst et al. 1952
1,300	....	Mule deer	Average all ranges	Arizona	Swank, 1958

[1]Based on animal units equivalent to one 1,000-pound steer.

uting to this biomass, especially in comparison with that maintained by domestic livestock in equivalent areas, one looks first to nutrition.

Food Habits

The forage in the study area is in the form of herbs, grasses, and woody plants, which range from low bushes to tall trees. In the open grasslands there are over fifty species of common grasses and associated herbaceous plants. It is possible to determine food habits by observation when animals are eating isolated, easily recognizable plants. However, in the case of grasses, where up to 20 species of herbivores graze the same bunch of mixed grasses, it is impossible to determine which animal is eating what grass by observation alone. Consequently, we based our food habit determinations from grazing animals on identification of stomach contents from collected animals, and mouth contents from many immobilized animals (Talbot, 1962).

Where possible, individuals of several different species were collected at the same time in the same place, so that any differences between their stomach contents would represent choice rather than local differences in available foods. Animals were shot through the neck vertebrae with hard-point bullets, dropping the animals instantly and quietly without disturbing nearby animals and without damaging internal organs. To further reduce disturbance, most animals were shot from relatively long distances, usually two to four hundred yards. For all larger animals we used a Winchester model 88 rifle in .308 caliber with a Weaver variable-power telescopic sight. Some smaller animals at closer ranges were collected with a scope-sighted Winchester .22 caliber rifle.

At the time of collection we examined the stomach contents, identified the items (using keys we had constructed and by comparison with plants growing in the area which we then collected for herbarium identification), estimated their quantity by two methods, and made sample occurrence counts. We then collected a sample of the contents which was given to Dr. and Mrs. D. R. M. Stewart of the Fauna Research Unit of the Kenya Game Department. They have developed a method of identifying the plant contents in stomach samples or faeces through microscopic examination of cellular structure of the plant epidermis. Their microscopic identifications provide a valuable check and confirmation of our macroscopic field identifications. In the case of stomach samples from 73 wildebeests, for example, the qualitative and quantitative results of the microscopic and macroscopic identifications closely approximate one another.

Results of these studies show that each species of ungulate appears to have a yearlong diet complementary to the others (Talbot, 1962). Some species of animals eat different classes of food. Giraffes for example, feed largely on trees; rhinos feed largely on brush, while wildebeests almost exclusively eat grass.

But within the different classes of food the diets are also complementary, either as to species of food plants eaten or to the stage of growth of a given plant. Red oats grass (*Themeda triandra*), for example, although not eaten by some ungulate species, is the most important single item in the diets of the wildebeests, topis, and zebras. The wildebeests choose the fresh leaves of this grass until they reach about four inches in length. Stalks and seed heads are rarely taken and only four per cent of the red oats identified in wildebeests' stomachs was dry. Zebras feed on red oats grass primarily when it is more mature. Most of the leaves eaten by them were over four inches long and stalks and heads were frequently taken. Zebras also avoided the grass when it was dry. Topis, on the other hand, showed a marked preference for dry red oats grass, and over 50 per cent of the red oats in the stomachs of the topis examined were dry. Most of the rest were mature, about 20 per cent stalks and heads.

The result of these non-duplicating food preferences is, as postulated by Darling (1958), that virtually all the available vegetation can be used efficiently to support the biomass of mixed wild herbivores. Whereas, when cattle, goats and sheep graze, only one class of food—grass—and only a few species within that class are the preferred forage and most efficient source of nutrition (Heady, 1960).

The individual diets of the herbivores appear to provide the optimum nutrition to the animals involved. The composition of the plants making up each ungulate's diet varies greatly in factors such as content of available protein and cellulose. Likewise the water requirements of the ungulates vary greatly, ranging from the wildebeests, which normally drink each day or two, to the Grant's gazelle (*Gazella g. granti* Brooke) and oryx (*Oryx gazella callotis* Thomas), which apparently drink no free water at all during much of the dry season. Physiological studies, undertaken in cooperation with the Animal Husbandry Division of the East African Agriculture and Forestry Research Organization, while not yet completed, indicate that the physiology of the digestive tract also varies significantly from species to species. It appears that the distinctive diets of each of the wild herbivores represent not only foods that are preferred, but foods for which the digestive system of each animal species is best adapted, although the animals are capable of surviving on different or more limited food if necessary.

Movements

The migratory herbivores maintain their preferred diet throughout the year by moving constantly to areas where rainfall and fire and sometimes grazing have produced their preferred plants at the preferred stage of growth. The wildebeests, as an example, are constantly on the move following rains which produce the fresh green grasses which they eat. Somewhere within the large study area even during the dry seasons, there are usually scattered isolated showers which will produce fresh sprouts of several species of grass within about 24 hours. The animals move to the area wet by the storm, often arriving before the grass has sprouted, then apparently waiting for the grass to come up. During periods in the dry season when there is no triggering rainfall, the wildebeests move in a roughly circular pattern following perennial water supplies.

Fire is very important in the area's ecology. Fires are lit by the local Africans for various reasons; we found no evidence of fires in the study area that were lit by any agent other than man. Much of the area is burned annually, and parts of it several times a year. The fires may serve to maintain existing grassland or create new grasslands. They also stimulate or at least make more available new grass sprouts, and clear areas of standing dry grass which is avoided by most plains wildlife. The location of fires, then is as important as rainfall in affecting the movement of migratory plains animals and allowing them to maintain their preferred diets.

Because of the irregularity of burning and rainfall, both in occurrence and distribution, no two years' migrations of plains wildlife will be exactly the same. Each species of ungulate follows a somewhat different pattern of movement from the others, depending apparently on the species² particular requirements for food and water. The direct line distance covered by some of these animals during their yearlong movements may be over 1,000 miles.

The animals that are relatively resident, such as impala and dik dik [*Madoqua kirkii thomasi* (Neumann)] alternate between eating grass, forbs, shrubs, and trees, depending on their availability at the desired stage of growth within their restricted home range, much as do some of our deer (Taber and Dasmann, 1958). Buffalo and elephant are both bush animals, but they make irregular and sometimes extensive movements within the bush habitat, probably correlated with availability of the coarse forest grasses which make up the bulk of their food, and on water.

Therefore the animals of the plainsland complex may be divided into two rough groups: the resident mixed feeders, and the migrant grazing animals. The nutritional requirements of the first group are satisfied yearlong within a relatively limited home range, while the nutritional requisites of the much larger latter group may be found at different places within the study area at different times of year. Therefore, freedom of movement over a large area is essential to maintain a high population of migrants on an optimum plan of nutrition.

Comparison with Modified Habitats where Migration is Restricted

This point can be further illustrated by comparing the study area with savanna lands to the east of the Great Rift Valley. These areas, once very similar to the study area in landscape and wildlife, have been severely modified by man during the past fifty years. Settlement, ranching, and other forms of agriculture have diverted water supplies, greatly reduced the grazing lands available to wildlife, and stopped or restricted migratory movements. Overgrazing by domestic livestock has altered the vegetation and lowered the productivity of the grazing lands that are still available.

In areas such as the Athi-Kapiti Plains in Eastern Masailand, immediately south of Nairobi, Kenya (60 miles of airline east of the study area) the plains of ungulates are now restricted to a relatively small part of their former migratory range. Being unable to leave this area to follow fresh green grass they must find yearlong nutrition from the often-dry grasses of these plains. Several lines of evidence—including age of females at their first breeding, timing and success of breeding, pre- and post-natal survival and differential sexual mortality of young, resistance of population to drought stress, and biomass—indicate that these conditions keep the animals on a low plane of nutrition. Wildebeests serve as example:

Under optimum conditions in the study area 83 per cent of the yearling cows and 95 per cent of the adult cows are bred annually; in Eastern Masailand yearlings apparently rarely breed, only about one third of the two year old cows and about 80 per cent of the older cows are bred. Pre- and post-natal calf survival is far higher in the study area where the calf:cow ratio at six months of age is 49:100 than in Eastern Masailand where it is 18:100 (Lamprey, pers. comm.). Survival of male calves may be another indication of the level of nutrition of the population (Robinette *et al.*, 1957). In the study area adult bulls outnumber cows (108:100), while in Eastern Masailand the reverse is the case (49:100) (Lamprey, op. cit.). During drought years in the study area the wildebeests moved away from the driest conditions, and no change was noted in reproductive success. In Eastern Masailand the wildebeests were unable to move away from the drought conditions and the population suffered accordingly. In the Athi-Kapiti Plains in the severe drought of 1961, no wildebeest calves survived, possibly one third of the adult population died, breeding was delayed about three months, and almost no calves were produced during the calving season of 1962. Prior to the drought, in the Athi-Kapiti Plains the biomass of three key wild species, wildebeest, zebra, and kongoni, was about 7,520 pounds per square mile; this biomass had dropped to 3,525 pound per square mile after the drought, due to death and possibly some emigration (Kenya Game Dept., 1962). During the same period, the biomass of these three species in the study area remained at about 16,890 pounds per square mile.

SUMMARY AND CONCLUSIONS

The biomass of mixed wild ungulates in East African savanna is very high relative to the biomass of domestic livestock on equivalent lands in East Africa, as well as to that of other wildlife populations in other parts of the world. When undisturbed, this East African wildlife does not overgraze and lower range productivity, while existing domestic livestock grazing in East Africa almost always does.

In addition to brush and trees, there are over 50 common grasses and grassland plants in the East African savannaland. The wild ungulate species demonstrate preferred diets complementary to—not duplicating—one another. These diets involve both different plant species and different growth stages of the same plants. These diets appear to provide the optimum nutrition to which the digestive system of each individual ungulate species is best adapted. Therefore all parts of the available vegetation can be used efficiently to support the biomass of mixed wild ungulates, while only a small part of that vegetation provides efficient nutrition for the domestic livestock.

Rainfall, grazing and fires determine the growth and distribution patterns of food plants available to the wild animals throughout the year. Freedom of movement over a large area allows the migratory wild animals to seek out preferred plant species at the preferred stage of growth and to follow their particular water requirements, avoids overutilization of an area, and reduces the impact on the animals of any but the most widespread drought.

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TECHNICAL SESSIONS

Wednesday Morning—March 6

Chairman: WILSON F. CLARK
Chairman, Division of Science and Mathematics, Eastern Montana College of Education, Billings, Montana

Discussion Leader: JAMES K. VESSEY
Regional Forester, Southern Region, U. S. Forest Service, Atlanta, Georgia

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CONSERVATION INFORMATION AND EDUCATION

CONSERVATION EDUCATION THROUGH IN-SERVICE TRAINING

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Conservationists are gradually becoming aware of the fact that we move ahead on the broad conservation front only as fast as the issues and needs are understood and supported by the public. The choices we make as a society, whether in the resource management field or any other area, are no better or no worse than the level of knowledge and attitudes possessed by the various interest groups and which ultimately is brought to bear upon the issues. For the major resource decisions are made and must always be made through our political system. This is a fact of life that we must always keep in mind.

Another fact that must be understood by the resource technician is that political decisions that affect resources are not based upon technical knowledge alone. If they were then surely progress in resource conservation would move ahead at a faster pace, for this is the area on which we have focused our attention over the past three decades.

The political decision per se is the result of compromise and accommodation among highly organized and vociferous pressure groups. Each such group has its own well defined philosophy which is based upon its interests and the values that it deems of paramount importance. A continuous debate goes on among the special interest groups and political parties wherein each tries to gain support for its particular beliefs. When the ultimate political decision is made, then, in a major sense, it is a reflection of what we hold to be of value in our society.

We have been accused of being a materialistic nation with good reason. We have made the acquisition of wealth our supreme goal and have brought into being a whole array of status symbols to portray our affluence. Among the more common symbols is the overpowered two and a half ton motor car which uses our limited energy resources at a prodigious rate. We have developed an economy of waste with its ideas of early obsolescence which put a added burden upon our diminishing resource base. We cannot afford, we argue, to clean up our polluted rivers or to make capital investments in our natural resources to keep them forever producing because it is uneconomical. This is an old story and you know the details. The purpose of this introduction is to mention again the scope and complexity of the task we have staked out for ourselves, and to illustrate the background knowledge that is a necessary prerequisite in developing well informed conservation leaders.

I now want to focus your attention for a few moments upon the problems an employer confronts when he attempts to make conservation leaders out of the technicians he has hired. Particularly, I want to talk about in-service training from the standpoint of giving the technician the knowledge and skills to conceive, organize, and carry out conservation education programs for adults at the local level.

There are two overriding reasons why resource agencies should engage in this kind of training activity. When you consider the vast number of technicians there are in private, county, state and federal employment, I am sure you will agree that a favorable impact on conservation problems would result if their abilities could be improved by just a little. Secondly, I think we should be concentrating most of our attention on adults because of the very good reason that it is the adult who decides whether or not conservation will be taught in the schools. It is the adult who decides on a buck-only season or an any-deer season. It is the adult who accepts or rejects new ideas and values and passes them down to his children. It is the adult who votes.

The technician who comes into the training program is a product of our technical training schools. He is well qualified in a technical sense for his first assignment. But he is ill prepared for the leadership roll he will assume after three or four years of employment. In-service training should be designed to bridge this gap.

One of the first problems that must be resolved in designing a training program is to devise a method for filling the academic voids in the background of the technician. These voids result from too much concern in teaching technical and vocational subjects to the exclusion of liberal subjects. The situation becomes acute when one realizes that education in a broad sense is a life-long process and is not limited or confined to the formalized sessions on the college campus. Specialized preparation leaves the technician without an adequate educational background to build upon throughout his career. Moreover, it probably accounts for his narrow outlook, interests, and poor reading habits. This background must be filled if the technician is to become a leader.

Certainly the technician needs a command of his specialty, but beyond this specialized knowledge the requirements of leadership demand that he have profound understanding of his own culture, its history, traditions, institutions, values and philosophy. For without this latter knowledge he is like a ship without a rudder. One of the goals of training is to provide the rudder. The employer is not equipped or staffed to meet this need—but meet it he must.

Leadership development is approached in several different ways. An all-out effort must be made over the course of the first three to four years to develop the knowledge and skills of the new employee and to persuade him to continue his education and self-development and to bring him to the realization that all development is really self-development and as such it is up to him. The employer can provide opportunities to assist the technician with his self-development but the decision to accept or reject them always remains the employee's.

At the very heart of the employee development program is the employee-counseling interview. Each employee is provided a set of performance requirements based upon his assigned job. The requirements are concise statements of how well the employee is expected to do each part of his job. At least annually the immediate supervisor is required to sit down with the employee to evaluate his performance against the performance requirements. Also at this time the Career Development Plan is brought up to date. The plan is prepared jointly by the supervisor and the employee. It is based upon the employee's particular needs and stated career objectives. Its purpose is to set goals, schedule training assignments, list appropriate books to be studied and to provide a basis for follow-up action to measure progress. The employee counseling interview, when done with skill and understanding, provides a strong incentive to improve performance and stimulate interest in continuing education.

The old proven principle of delegation of authority and responsibility must be used from the outset. The technician is assigned duties and responsibilities which stretch his capabilities. He is put on his own and forced to make independent decisions. Competence or the lack of it will be evident before too many years pass. Of all the elements that go into a training and development program the effective use of the delegation principle is by far the most important one. Skillful day to day coaching and counseling must be a part of the delegation principle; otherwise, the technician runs the risk of developing poor work habits.

Another technique used to simulate self-development is the group training sessions. They are scheduled over the first four years of employment for all new technicians. The first session is a course in oral communications. Its purpose is to develop instructing skill. It covers the principles of learning, analyzing, and organizing subject matter through the preparation of lesson plans, practice teaching to develop skill in presentation, and the effective use of visual aids. Following it in rapid succession are courses in human relations, internal and external relations, introduction to the principles and functions of management, and a short course in communications with emphasis on the sociological and psychological aspects of the subject.

Also included in the formal groups training sessions are sessions on group dynamics and community relations. These sessions give the new employee an understanding of how communities are organized and function and how individuals and groups accept new ideas. These sessions are particularly important because they are an introduction to the area of adult education's methods and techniques.

Simply knowing the principles and techniques of adult education is not sufficient. To reinforce his newly acquired knowledge, the employee is encouraged to participate actively in community activities. There is no substitute for actual experience in developing social skills.

There are other important aspects of participation in community activities. It gives the employee an insight into how a community is organized into interest groups and an understading of the interplay between these groups in reaching community decisions. Wholehearted participation in community life develops an awareness and sensitivity to the attitudes, needs, and limitations of the citizenry. It develops respect, trust and close personal relationships which are fundamental to the success of any adult education program.

The process of interesting community or group leaders in conservation problems or new ideas is a two way street. The technician must first become deeply involved and sincerely committed to the problems of the community before he is fully accepted into it. Until he is fully accepted by the community he cannot hope to interest its leaders in his ideas and problems.

The active participation in community activities when it is accompanied with know-how and purpose is self-education and self-development at its best. The community in which he lives becomes his classroom. At this point he should have the knowledge and skill to organize and carry out an effective adult conservation education program. The only limitation is his own drive and imagination.

The subject matter in the concentrated training sessions is geared to the technician's level of understanding and his needs to do his job better. There isn't time to give a full course in philosophy, economics, political science, sociology, psychology, anthropology, history, or literature and so forth. All that can be accomplished in the short time available is to whet the technician's appetite and then hope that he will be stimulated to pursue a purposeful course of self-development through self-education.

All technicians are given the same basic group instruction during the first five years of employment. After this period, training becomes more selective. Technicians develop and grow at different rates and some don't at all. Those that respond to training by showing signs of intellectual curiosity are singled out for additional leadership instruction. They are sent back to college to broaden their educational base or to gain additional training in their chosen specialty.

There is no simple formula for developing a technician into an able conservation leader who has imagination, judgment, sensitivity, knowledge and the will to become a crusader. If the resource technician is to have a voice in shaping resource decisions he must begin at an early age to prepare himself for the task. Being master of his own technology is not enough. He must discover how his technology is related to and affected by the cultural values and political system of which it is a part. Beyond this he must develop social skill to become effective as an individual in the situation in which he lives.

DISCUSSION

MR. JAMES NEWMAN [Wisconsin State College, Stevens Point]: Mr. Trosper, you are speaking of in-service training as apt to broaden the resource techniques. Would you, if you could have an ideal situation, rather see the undergraduate broadly trained and then be given a special field on top of that? Do you believe that the agency would be better adapted to aid the technician specializing in his field and let the college teach the broader aspects?

MR. TROSPER: Of course, I would advocate this very strongly. I think that in our school curriculum we've got the cart before the horse, and we recognize it now. Thirty years ago, there was a need for developing trained technicians. We didn't know much about the subject matter. Today, I think the need has shifted. I am not saying we don't need technicians—I think we need good technicians, and research people—but I think we've got to get these people back into college and give them more specialized training in a field of their interest. What we are trying to do now is to make a research man out of each individual. If you look at the curriculum, you will see it is tremendously vocational and technical. It is loaded with applied subjects. I would make this recommendation: The school should stick to the basic course subjects, mathematics, ecology, chemistry, physics, not get too deeply into specialized subjects and some of the others like surveying. We spend a lot of time teaching college boys this. Now, the agency is equipped to teach technology. If the individual has a real good academic background, then we can take up from there and actually teach the man what he has to know. They can teach him how to mark timber and management systems. If he gets a good knowledge of mathematics, it wouldn't take long to get him into statistics and to get him into management planning, but our problem right today is that we get the technician and he has nothing to build on. We need several kinds of people, we need research scientists, but our academic program today is not building the broad person who has the overview of the broad problem and can relate all aspects of it, so I would certainly agree with you that we could change our curriculum this way and I would be all for it.

MR. LEE HOVER [Arizona]: Mr. Trosper, the information and education division of a game and fish department should not have in its public relations department, a person trained to be an interpreter? The technical knowledge that our field people and our biologists and technicians have is too dense for the public. The first and primary training in public relations is in journalism school. The public relations people are the ones that are going to have to put this in lay writing and do the education. Another thing we need in this business is to put a good old American word back in our language, which is square, square shooter and square dealing. Too many of our young people today, when referring to something as square, mean an oddball. I think we could have some more squares. But the question is, do you think that I and E men, should be trained in public relations in journalism school?

MR. TROSPER: I can't answer that question yes or no. One of the failures of I and E is actually that the I and E person has to know something about the subject matter in depth, and there is a danger in just interpreting the information. It is a lot deeper than that. The problem is one of education—one of educating the lay public, not merely one of informing the lay public. The danger is in just having men trained in journalism with a very scanty knowledge of resources. I think this sort of man has a place in the I and E function, but I don't think he has the key place. He would serve as a staff specialist to assist the manager or the line officer, in rephrasing technical material so it can be understood by the public, but if you had just a journalist as the I and E man, you are in danger of getting into a propaganda campaign to build the status of the organization. I think we always have to be guarding against this particular danger, and this is one of the reasons why I and E men have this communication difficulty. It isn't so much the facts the people don't understand, but there is a disagreement on what the facts are. There is no substitute for knowing the subject matter.

CONSERVATION CONCEPTS AND STANDARDS AND THE ROLE OF EDUCATION IN THEIR DEVELOPMENT

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In this discussion, it is our purpose to consider the manner in which resources and their significance and uses can be evaluated, interpreted and transmitted into courses of action of benefit to society. These considerations must be related to and are evolved from public attitudes, which determine the direction and development of what we call culture; and that culture is conditioned by understanding which leads to definitions of purpose and intent. Understanding and purpose, therefore, determine the directions and interpretation of what resources are, and the manner in which we use those resources.

When we consider resource uses, we are, first of all, dealing with a concept we have defined as "conservation." The definitions and interpretation of that term have set the course, along which we have ventured to apply this concept. But one of our greatest difficulties in determining the relative significance of resource uses lies in the fact that *we have no clearcut understanding of just what conservation means to us or to our society as a whole.* Nace (1961) has, for example, referred to conservation as a term that means " . . . all things to all men." He further observes that "all land and water developments (in this day) are called conservation." While (Sears, 1939) has referred to our conservation concepts as being comparable to " . . . the classic Mother Hubbard dress (which) . . . can be made to cover a great deal of territory without touching any very vital spot." Thus, the very looseness of the term and its use to justify and define all manners and kinds of ideas and actions affecting resources is one of the principal problems we face.

Many people have attempted to give us an adequate definition for conservation from which we could evolve guide lines for action. It has been called a "policy of prudence and care" and one writer, (Ogburn, 1960), has defined it as a ". . . concern with what men live by . . . to preserve a world that we can feel we belong to and can expect to endure." Sears has observed that "conservation can't be taught, it is a way of life." But it is certain that we must develop some clear-cut understanding of what the term means before we can evaluate its purposes or promote the ideas which that term represents.

It is notable that the conservation idea developed around the turn of the century when it became apparent that our material resources were disappearing faster than they could be replaced. Prior to that time the pattern was one of exploitation without consideration for the future. Concern with resource depletion was publically demonstrated at the "Governors Conference" called by President Theodore Roosevelt in 1908. ("Proceedings, 1909). At this meeting the primary concern was with depletion of land and water resources essential to an affluent society. The agenda included discussions of soils, forests, sanitation, reclamation, grazing, and navigation. This meeting was the outgrowth of an immediate concern with river navigation problems; and it is notable that "wildlife" was not listed as a subject for discussion among the 41 topics presented. One participant, however, (Dr. George Kunz) expressed concern with the preservation of "scenic and historic" resources. He discoursed at length on the potential loss of scenic and esthetic resources and stated, "We have seen that there is no more valuable agency than that of the scenic beauty of the forests, of the mountains, and of the rivers and their banks toward the creation of an esthetic taste and a love of the beautiful in the average mind," and he noted that the " . . . prevention all together (of certain types of developments such as impoundment of streams) . . . may induce to the greatest good." Such an expression at this meeting was, however, unique, and was not in keeping with the major concern—the material wealth and economy of the nation.

In 1963, we have new problems not then anticipated. We are confronted with such problems as preservation of space, of vastly accelerated population growth, of great surplus of agricultural crops, of juvenile delinquency, the atom bomb, and the very survival of man under the conditions imposed by his technology. In short, we have a whole new manner of existence calling for the development of new patterns of thought and response to change.

Today, one of our greatest problems is the system of resource uses established during the early period of our development as a nation, due to the "guide lines" which separated one type of resource use from another, and the establishment of specialized agencies of resource management. Today those patterns have become a hindrance to the establishment of conservation concepts which permit consideration of many values inherent in our resources. With this situation in view, Nace (1961) commented ". . . traditional concepts of protection and development are naive in relation to the complex pattern of land and water problems in a mature society. (Traditional approaches) . . . are not sufficiently sophisticated for current problems. Its inadequacies will be dangerous in the future . . ."

I think it is self-evident that preconceived patterns of resource use and development are outmoded. Yet, through established patterns of use, traditional systems of economic enterprise, organizations with preconceived methods of resource development, and through the narrowly conceived objectives and authorizations defined by custom and carried out by vast and long established governmental agencies, we are, as one writer put it, "freezing resources in inflexible patterns of use." Today neither the philosophy or the systems we employ are adequate to meet the changing needs of our society, or to cope with the new problems created by technology.

While attempting to hang on to our old outmoded systems and maintain the established (and sacred) order of responsibilities and authorities, we have, it seems, become aware that both our methods and organizations are inadequate to cope with the new problems confronting us. To compensate for such deficiencies, we have cloaked all resources with the "garb" called conservation. Every social group and agency has defined its purposes with the high-sounding connotations of the term, and many agencies, in order to fulfill their obligations to the concept, have organized their plans to conform to "multiple purpose" systems. All resource developments are, therefore described as "conservation" no matter how or to what extent they may cancel out each other.

We have many examples of conflict in the application of so-called conservation principles. Such conflicts are particularly aparent in land and water developments. Conflicts in wetland drainage, which has eliminated a large percent of our waterfowl breeding grounds, and the avowed purposes of the program, *i.e.*, to drain wetlands for agricultural use (and to, perhaps, produce more votes), are incongruous with increases in the vast agricultural surplus which we must store at public expense. This is one example of single purpose resource development without consideration of the many values inherent in wetlands as a resource, and the scope of the many problems involved.

The system of allocation of water to "single" or "multiple purpose" uses, has been described as "appropriation" of water for limited purposes which preclude its use to fulfill other needs. Nace (1960) has noted that "approaches to these (water) problems have been and continue to be rather strictly engineering in orientation," and " . . . the unforeseen or ignored 'side effects' of engineering manipulations set off chains of unwanted consequences which tend more and more to vititate the whole purpose of development . . ."

Pollution of water, based on established patterns of use, timber management with only immediate economic returns in view, and even the watershed program (generally accepted as a proper application of the conservation principle) all have ramifying effects without sufficient consideration for their total effects on other resources and on human environment.

The scope of developments and their ramifications and effects extend from alterations in water flow patterns and the wide diversity of human needs to the burdens of taxation which bear down on the living and the yet unborn.

The problem of pesticides and their use is a critical one. The narrow and "single objective" approach with undetermined effects leaves us with immense areas of unfulfilled obligations, to other organisms, to a full consideration of the problems presented, and to future human generations. The fact that 6,000 commercial brands of pesticides are being sold leads to the assumption that monetary considerations supercede all others, even the health and welfare of the biotic community and of man.

If we are to evaluate resources fully and their relation to human welfare, we need a better and more inclusive interpretation of what "conservation" means. An adequate conservation concept must encompass all human needs. Its application cannot be restricted to material needs. It must recognize and include all elements of our culture, and encompass emotional, esthetic and sentimental values which "give meaning to life."

A major problem in resource use evaluations is that we now have no standards for recognizing or placing values or qualities in our environment which are spiritual and esthetic, though "these values exist" and are essential to our culture and welfare. The "fiscal yardstick" is not enough to measure all our needs, but commonly applied standards for evaluation of the worth of our resources provide no other criteria for judgments essential to an adequate concept, and present applications of the "multiple use" idea are "inadequate for the kinds of decisions now in prospect." (Clawson and Fox, 1961). Skutch (1949), commented ". . . there is only one conservation and the lack of it . . . nature is not a series of isolated, but a single vast complex . . ."

Until what we call conservation embraces a wider view, what we have to sell or promote is only a reapplication of a monetary principle, too narrow to satisfy the needs of society in the troubled days ahead. We need a revision of goals and purposes sufficient to recognize "the spiritual, emotional, and ethical needs of society." Without this, our efforts lead only to a cultural desert.

AVENUES OF COMMUNICATION

In preceding paragraphs we have attempted to define deficiencies in the conservation concept, which limit the application of principles to purposes. A restatement of purposes is imperative, if we are to accomplish our objective: This is probably the most critical and most difficult of our tasks.

Beyond this, our efforts must be extended into the fields of education, politics and legislation. Education is our first approach, and probably the most important. Without understanding on the part of the educator and educated, we cannot influence actions which determine the course of resource use.

It is my belief that our educational efforts have fallen short of what our goals should be. The educator has not recognized the scope of the problems presented. His efforts have been particularized and specialized. This is equally true of the resource scientist, who has often given his efforts "to objectives which have little immediate or even distant bearing on those critical problems which directly effect our survival and our manner of existence." (Alexander, 1954).

In a recent check of abstracting journals covering the conservation field, it was noted that there was vastly more concern with and effort given to particularized studies than with evaluation of purpose or concern with the problems which dominate the patterns of resource use. The papers covering the fundamental concepts of conservation were few and far between. Most papers abstracted were concerned with techniques, control, food habits of wildlife, life histories or disease. In a major journal over a two-year period (1960-1961), there were 153 references on waterfowl food habits, life histories, and other "species studies" and only 13 references on wetlands. Since preservation of wetlands is the key to waterfowl survival, it is incongruous that we, as conservationists, should be more concerned with such details than with the problem of saving ducks.

It is apparent that we often give our time and efforts to objectives which migh be deferred until we find solutions to the critical problems we face. We "fiiddle while Rome burns," and our efforts have often been inconsequential and ineffective. Our main purpose should be to preserve a world "which we can belong to and expect to survive."

We have examined the need for revision in our systems of values, in the critical nature of our problems, and in the causes of some of our failures. The methods of accomplishing what we are after are the keys to achievement of purposes. These methods must recognize social attitudes and their modification, systems of law and government, the forces that dominate systems of resource management and what we call politics.

Social attitudes can be modified by education, and there are many avenues of approach.

As we have noted, initially, our first task lies in revising the concept of conservation to include many things beyond and in addition to material values. These include those intangibles that give "meaning to life." This necessitates revising standards, attitudes and practices in vogue. In this task the educator can lead the way, if he will, but he must first re-educate himself.

He cannot, for example, continue to "bury" his knowledge behind barriers of scientific jargon, or communicate only to his professional associates. He must make his knowledge available to those who effect the course of progress. Likewise, he cannot lead the "ivory tower" existence which often shields him from conflict and controversy. His knowledge and status as a specialist qualify him to lead the way, and he must not shrink from that responsibility.

The media for educating are well known. They include the schools, the journals, publications, TV, and even "lobbying" in the town square. We have, as yet, many unrealized opportunities in the fields of education. Even conservation textbooks are inadequate, are largely concerned with use of resources for profit, and are ineffectively used in the schools and colleges. But the schools, because their business is education, furnish one of the best opportunities to get conservation across to a large (and available) audience.

Recently established extension programs and "conservation supervisor" systems in the public schools are most effective ways of presenting ideas. Such positions must, however, be occupied by individuals with knowledge and broad vision who are dedicated to the purposes they seek to attain. Educational processes can be a repetition of old ideas, or a dynamic interpetation of new concepts—the interpretation depends on the "interpreter."

As we have suggested, our biggest problems today in resource conservation are created by established attitudes and systems which defy change, and by the impact of our technological capacities to change our environment. Governmental agencies, with limited purposes and high degrees of specialization and influence, present one of our major problems in changing the conservation viewpoint. These agencies are supported by social groups and forces which they benefit, and by a monetary system backed by billion dollar budgets. Giving a wider perspective to conservation, as practiced by these agencies, is handicapped by their separateness, singleness of purpose, specialization, and political (meaning economic) strength.

The approach to alteration of these systems of politcal enterprise is most difficult, but further application of the "multiple use concept" is not the answer. But resource developments which alter environment, however they are accomplished are everyone's concern in a democracy, and many of the changes being brought about in our environment are "terrible permanent."

Present systems of resource management are inadequate or have outlived their original intent and usefulness. They fail to include many important considerations. Changing these systems involves not only education in new ideas by political maneuver and the revision of legal authorities. But, (Taylor, 1961) has observed, "The law, itself, may be used to reap enormous rewards, at public expense, as through subsidies or the tax structure." The solution to these problems lies in education and in taking sides on issues involving the principles we support. "There are, after all, few matters of large moment that can be determined without . . . pleasing or offending one group or another." (Taylor, 1961) As conservationists whose purpose is promoting a better way of life, we cannot avoid conflict, and we must not shrink from it.

We must recognize that congressional or legislative action passes on most of the legislation which now determines resource use, control, or development, and that this legislation involves actions which are in acute conflict. Much of this is influenced by special interest groups who organize to promote their particular purposes. The process is called "lobbying."

John Dingle once commented that "conservationists . . . are sufficiently numerous to be an almost irresistible lobby if they are sufficiently organized." We are, to a large extent, ignoring this technique for promoting our ideas, but function as isolated groups, weak and relatively ineffective. There are some exceptions and shining examples which contradict this contention. Basically, however, our efforts are scattered and often limited to protecting remnants of such things as isolated bits of scenery, rare species, and occasional concern with principles. Unification of effort is essential, if we are to preserve opportunities for "diversity" in our environment, and education in the effectiveness of group action is needed.

CONCLUSIONS

We have briefly discussed three avenues to better resource use evaluation, and approaches to a better interpretation of the conservation concept. We have noted the need for education, the necessity for concern with pertinent problems, the importance of using our talents and knowledge to promote ideas, and the fixed patterns of use determined by tradition, social attitudes, legislation, and political maneuver. We have noted that a better approach to conservation must involve use of all avenues for education, for communication, and for a positive assertion of beliefs and principles, and we come full circle to the original premise, that "conservation does not provide a suitable philosophy around which we can build social progress, unless it encompasses a fundamental concern for the preservation of the whole environment of man, including not only his material needs but the spiritual, emotional and esthetic values which "differentiate him from the ape."

The achievement of these goals depends on all of us, and we must work constantly to achieve these ends. The forces that defeat our efforts lie partly within ourselves. They are the result of scattered efforts, inaction, and divided effort. They are, to some degree, exemplified by the plight of the Athenians who were addressed by Demosthenes in these words:

"The worse feature of the past is our best hope for the future. What, then is that future? It is that your affairs go wrong because you neglect every duty, great or small. Since surely, if they were in this plight in spite of your doing all that was required, there should not be even a hope of improvement. But, in fact, it is your indifference and carelessness that Phillip has conquered; your city has not been conquered. Nor have you been defeated. No, you have not even made a move." (Taylor, 1960, quoting Demosthenes.)

The development of an adequate conservation concept, and constant efforts through education and persistent action are necessary if we are to achieve our aims—the preservation of an environment which will contain all the material, emotional, and spiritual needs of man.

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DISCUSSION

MR. VESSEY: Harold, in my opinion you are right on the beam. Our subject is one that has been close to my heart for 20 years. I have been stumping through the nation beating the drums for conservation, and particularly a realization of the basic reasons for conservation. Now, I am sure there are many of you who have what you are sure is your conception of conservation. I imagine if I were to ask for them, I would find 40 different approaches.

MRS. GRACE MURPHY (Setauket, N. Y.): I am totally deaf, as many of you know, and that presents a lot of complications, but I am doing good conservation work, and I think we've got to get outside the classrooms, and outside the colleges. We must get to the public and give them information. But not just information. We must give them a thorough understanding of the problems. We cannot stay strictly in the classrooms and solve this problem. Now, I suggest we have a conservation knowledge dispensing organization which would be an arm of the news. I imagine everybody in our field could contribute to this and we could get information from all sides. I believe what we need is a clearing house for us conservationists and a clearing house for all industrialists so that we know their problems and they know our problems. This conservation clearing house could be partially staffed by journalists who could disseminate our information much better than we can, and another way in which they would help is that the releases would be brief. I think one of the worst faults of our conservationists is that they use oceans of words. Nowadays, nobody has time to read long things.

MR. VESSEY: You have given enough for this fellow to make some answers. We thank you. Will you talk to those points?

MR. ALEXANDER: One good point in particular that you made is that nobody has time to read the range of information that does come out, and there needs to be much more information put out in the form that the Wildlife Management Institute and National Wildlife Federation use as bulletins and so forth. I am particularly impressed with the job they do in bringing attention to various kinds of legislation and congressional actions that refer to conservation problems. In fact, that is an excellent source of information for many of us who must keep up with what goes on. Since we must be concerned with laws, any avenue that gets these things back to us without having to go through many documents would be good.

MR. LESLIE DIX (Defense Department, Washington): I cannot help but recall a year ago in Denver when then Governor Nelson—now Senator Nelson—from Wisconsin made a very eloquent, and I thought basic, point on behalf of the fact you have to have a broad base of power to get votes, to get the nomination, and to get the organization to work. This is perhaps within the dominion of the layman as with respect to the skills sought. Therefore, I thought that we should be greatly encouraged to see such people as Walter Reuther, for example, see fit to come before the Federation last week and to espouse the cause of conservation in terms of a belief in the movement. Now, if everything is a power play, and I guess it is, I think you might want to incline your attention to increasing the adeptness of the I and E medium to achieve a liaison with such groups. On the other side of the coin of the labor movement, I think the national business associations are very active, and if they can be convinced to the point that they would put their money and time behind you, then you would have a substantial member of this great fraternity. The American Bar, of which I happen to be a member, I think should be perhaps taught and led to believe that indeed this would be self-serving to them as well, and on and on across the various groups that do muster susbtantial votes, but above all, power in this country. You can't think in terms of watersheds when it comes to power, or parts of states or districts of states. You have to have a wide broad-based voting power. You get those people with you and I think we will find that soul in Washington will be much more attentive to your demands. There is no doubt in my mind that a water bill will pass much easier if the congressmen who oppose it have a lot more to be afraid of. Thank you.

MR. ALEXANDER: Well, I certainly agree that we don't make use of the powers that we possess and we don't concentrate our efforts. We sometimes don't impress the right agencies and people with our thinking.

I have another question that was handed to me that inquires as to why we don't more often get into the newspapers and on the radio and TV on both sides of an issue, and that certainly is a problem. We can only evaluate things insofar as we are able to see all aspects of them. We must be able to look at all angles and meet this problem of resource use. We are very often presented with only four or five, or one or two, alternatives, and there may be 50. That fact, I believe, is another crucial problem. We are not permitted to see, and we are not given information enough so that we can see all these points of view, and of course, I think that one of our problems is something other than a monetary standard to these things. We can't compete with other resource uses, particularly on wildlife when we have to say this is valuable in terms of so many dollars, and somebody else estimates another dollar value for another thing, and it can easily be qualified at a much higher rate. Thank you.

THE NEED TO DEFINE CONSERVATION CONTROVERSIES

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There are few people today who would seriously argue that soil conservation is an over-rated virtue or that the sustained yield management of forest lands is an unsound concept. I don't think very many people would advocate that the National Park system should be abolished, or that the Nation's wildlife should be denied habitat, sanctuary, or food. And I doubt very much if a political candidate who campaigned in favor of soil erosion, or in favor of water pollution could expect to garner very many votes among the citizens of any State.

What, then, are the conservation issues for today? Are there any issues worth getting excited about? Must a person be a Malthusian pessimist to be worried at all about the problems of conservation? Or have we come so close to solving all of the natural resources problems of the world that there just isn't anything left to be concerned about?

And why is it that even with a large measure of broad agreement on many of the fundamentals of natural resource use and conservation—why then is there such violent disagreement on specific conservation jobs—pesticides, dams, grazing policy, land acquisition by public agencies, wilderness preservation, wetlands drainage, and so forth?

In my opinion, at least part of the trouble lies in the failure of many conservation educators to face up to the really important issues of conservation. Teachers, professors, State conservation education employees, and Federal conservation educators have all too often ducked the major issues in favor of the ''safe'' ground and sheltered security of the relatively non-controversial ''principles'' of conservation.

Of course, principles are necessary, and it is important that young people, students, and the adult community understand the broad principles upon which the decisions of conservation are based. It is also possible to get a dandy argument going among conservation educators about what the conservation ''principles'' are. Though there is a great deal upon which most everyone can agree, there are still many areas of resource-use principles that can draw heated argument—the ''principle of dilution'' as an answer to industrial and municipal pollution is a good example.

But by putting all our efforts into ''principles'' we dilute the real issues and I am afraid we give many of the young people we train the completely wrong impression that conservation issues are somehow capable of being divided into blacks and whites, into rights and wrongs. Too few people are adequately informed about what the issues are.

There are some good reasons why this happens. Part of it happens I think because many of us in the field come out of the natural sciences. I suspect Arnold Bolle is going to have some more to say on this subject as soon as I finish, so I won't take anything away from his subject. But I think it's important to keep in mind that for all of the technical considerations involved in natural resources actions, the greater part of the really important decisions made are essentially ''political'' in nature—judgments expressing social values and having generally definable social and economic objectives. Though there are, to be sure, technical reasons why a forester would argue for or against large, long-term timber sales, the final decision about whether to offer such sales is essentially a political decision involving very complex issues of large business versus small business, imports versus exports, levels of utilization, wage-price relationships, and so forth.

Discussions of the ''principles'' of conservation and education about only the broad areas of existing agreement, often miss these real issues completely.

There are some other very important reasons why issues get ducked. For one, the Congress itself has never been very sympathetic with any Federal information and education program that tried to grapple with real issues. And this happens in spite of the fact that four-fifths of all candidates for the Congress polled last year by the Associated Press Managing Editors expressed the opinion that the public should have the right to all information about their government except military secrets.

The history of federal conservation activities is strewn with the wreckage of many dismal failures among a relative handful of minor successes. State agencies have many of the same troubles in their relations with elected or appointed commissions and the State legislatures.

And here I must observe that there are some very valid reasons for this concern on the part of Congress. Information and education programs have a very special place in American Government. And it is often a very uncomfortable place because the Federal Government—at least the Executive Branch—is prohibited by law from lobbying or attempting to exert influence on the course of legislation through Congress. But there is an obvious paradox here, because it is certainly an established fact of American history that no government has ever seen a clearer need to build its consensus on an informed public—and I submit that our record is quite good.

But this doesn't help resolve the paradox. It does put on government administrators and information and education personnel an enormously difficult burden and responsibility consistently to understand the sufferance under which they are allowed to operate in our political system.

Nor do I think the Federal and State administrative agencies yet fully understand the nature of their educational and informational responsibilities. There's many an administrator who is far from willing to concede virtue to universal public knowledge of what he is doing. And here, too, the uneasy balance between responsible information and education, and bureaucratic aggrandizement is difficult to maintain and sometimes impossible to define. Government agencies—like their private counterpart—have a built in hazard in a common urge to orient the entire information and education effort around the agency. Part of the reluctance many people have to conservation education stems from their native refusal to submit to agency oriented propaganda. And "Hurray" for it!

At least for the present, the great burden of defining and articulating the important conservation issues of the day must fall on the private conservation organizations, citizen groups, and individuals.

But is this asking too much of a myrid of organizations that are themselves pulling and tugging in a dozen different directions? How far does an organization dare go without jeopardizing its tax exempt status? Here, too, the political paradox in which the information and education function finds itself again comes into focus.

I wish I saw some easy answers to what have been mostly questions raised by this discussion. I really don't think there are any easy answers. But I am quite optimistic about future prospects, because I think that under the present leadership of Secretaries Udall and Freeman and President Kennedy, we have seen a sharp increase in broad public awareness of the importance which natural resources play in the lives of every citizen. The roots for this growing interest go back a number of years, but it is now being brought into sharper focus.

But I think conservation educators, both private and public need to take a long hard look at the substance of their programs. Are they really getting across to the public and to the students the basic issues and ideas with which they'll be asked to grapple and on which they'll be asked to make intelligent judgments and political expressions? Or have we so diluted the issues as to miss them entirely?

I was very much impressed by a recent discussion in the annual report of *Resources For The Future* in which Dr. Joseph L. Fisher observed "Resources education finds its ultimate justification in promoting creative change." And here it seems to me is a basis for optimism about the future with a growing new public awareness of the importance of natural resources and conservation in their own lives. It is becoming more and more the task of conservation educators to give this growing awareness the food on which it can feed its thirst for knowledge.

This means giving people facts, it means giving people ideas, and in doing so we will furnish the public with those rallying points by which the forces of political action can be brought to bear on the major conservation issues of our day.

The important goal for conservation education in the decade of the 60's must be to distill and crystalize the ideas and issues which confront our civilization. This task is made doubly difficult by the restraint which conservation educators must place upon themselves never to cross the line which separates them from the professional lobbyist and the Madison Avenue product promoters. I do think, however, that conservation educators must walk up *to* that line more often than they have in the past.

DISCUSSION

DISCUSSION LEADER VESSEY: I find it difficult to keep within the bounds of the discussion leader and not become one of the discussers. I would like to observe that the controversy, if kept within reasonable proportion, is not necessarily bad. It creates the heat which arouses interest and gets people to learn a little more than they might if things were just cut and dried. I would also like to observe that these last two papers implied to me the thought that our technicians in conservation, whatever phase you want to name, at least there are many of them, must become concerned with, involved, and proficient in this so-called socio-political phase of conservation.

MR. CLEMENS [National Audubon Society]: I want to congratulate Mr. Rettie on his presentation and suggest that there is another very fundamental paradox that we must face and resolve. That is that the last 300 years in this age of reason, we have increasingly devoted ourselves to an almost entirely technological approach, and that the opportunity of the conservationist is to reintroduce a sense of humility based on an ideological approach. Our ability to contribute to the solution of this dilemma arises in the fact that as ecologists and only to the extent that we are ecologists, we have hold of the realities of the man-bird relationship that has to be the basis of a solution to the future, in my view.

MR. RETTIE: I don't know that I can really add anything to that. I would have to say that I agree with it. I would, however, make this one additional comment: I think the dangers from tending to lump together the professional specialties as if they had a monopoly on the correct approach, if I can use that expression, to conservation problems, is a very dangerous one. I agree that the ecological approach can give us a great deal, but I think, and I am sure the questioner would agree with me here, that the variety of skills and attitudes, the variety of disciplines necessary to be brought to bear on conservation problems is a very broad spectrum ranging all the way from the natural sciences to the most sophisticated of the social sciences, and it is only in this way that we are going to find some sort of intelligent synthesis and, in fact, a realistic synthesis of the solution for the conservation problems in the future.

MR. VESSEY: I am sure there is more discussion to be applied to this subject. If I have some time, I will ask one myself. What responsibilities do federal agencies have to building public understanding, since you are tending to throw the ball back to the professors?

MR. RETTIE: I didn't intend to throw the ball back to the professors at all. I was trying to suggest that part of the resolution of the political paradox within which education and information people find themselves is in the awareness that the private agencies on the large part must be the ones who can be at the vanguard, as it were, of the major conservation issues. There is a great deal the federal agencies can do, and a great deal the federal agencies have not yet done and are not doing today. I would say that the thesis of my paper suggests that federal agencies should step up as close to this paradox as we can possibly get without stepping over it. It is very difficult, and sometimes hard to find the line.

MR. VESSEY: I've got one more question if you folks don't come through. How can your agency spark its own personnel to better see that each technician has obligations to contribute to building public understanding, and what are you doing?

MR. RETTIE: Well, I am faced with another paradox here of talking to oneself as opposed to talking to the public, and I think the resolution to the paradox is, in effect, fighting the battle on both fronts. As I suggested, it is a simple fact that many administrators at all levels of government, and in fact, many private administrators as well, do not see for themselves yet a clear information and education responsibility. A professional information staff must itself assume part of that responsibility to educate their own colleagues within the organization as to the role of effective information and education programs in the agencies operations. At the same time, I think there is a great danger of overdoing this. I also think that there is a great danger of neglecting the broader and really more important, in the long run, responsibility to the public itself. The problem is a very acute one, and it is one which requires spreading I and E people exceedingly thin. Most information and education efforts at federal, state, and city levels and also private organizations ,are understaffed, underpaid, underfinanced, and there is a necessity for selecting those areas where you are going to put your effort.

EDUCATION FOR RESOURCE MANAGERS

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Natural resource conservation is a principal concern of our society. To promote a broad and effective conservation program our people have given discretionary powers to resource managers—depending on them to define and protect the public interest. The establishment of government technical agencies has taken resource management out of direct politics and placed it in the hands of professionals. This professional structure within government is the foundation of our conservation programs. We believe that the public interest is better protected, that the social values and scientific problems involved in resource management have more chance of objective consideration and rational solution if approached by trained appointees rather than elected administrators. We realize, at the same time, the problems inherent in such "professional government."

Society's decision places resource managers in positions of leadership—leadership which demands more than technical excellence in some specialized resource field. Society's interest is based on the flow of products, services, and satisfactions provided by natural resources—on the contribution of resources to the maintenance and enrichment of human life. The resource manager must understand and meet these social needs. He must also project the inevitable changes in these needs. Relating present resource problems to social demands of the future, he must have the creative and administrative techniques necessary to develop appropriate programs. Close and active relationships between resource agencies and between the agencies and the public are required. The resource manager must establish and maintain these relationships at all levels.

Recent public criticism indicates that society is not too well pleased with the present performance of resource managers. Dissatisfaction has been expressed in magazine and newspaper articles, letters to public officials, and so forth. Most of these communications complain of individual actions, and in most cases the manager can prove himself correct on technical grounds. The sum of public opinion, however, shows discontent with the means employed by resource managers in making decisions. Their objectivity is questioned. Instead of considering the total needs of society, managers are accused of leaning too much toward particular users, especially those who apply the most direct pressure.

This criticism is frequently justified. Too specialized an education has limited the perspectives of resource managers—they are not receptive to ideas and attitudes outside their own fields. Their education has led them to apply answers and solutions without understanding the problems. They tend to think of themselves as owners of the resources they manage and to develop an "elitist concept"—as though they possessed inborn knowledge of what is best for people, how resources should be used, and what users should have preference.

Some time ago I corresponded with many employers of resource managers. Their criticism was: "College graduates in most resource fields, while having a sound knowledge of their specialty, have little understanding or appreciation of related resources and even less understanding or appreciation of the civilization in which they live." This is a severe indictment and, if true, explains society's growing dissatisfaction with resource management.

The problem of the resource manager's education is the problem of compulsory specialization. There is no other way to encompass the rapidly expanding fund of resource knowledge. So much is being learned so fast in each separate field that natural resources generally are undergoing an information explosion. It is no longer possible for any one man—like Sir Francis Bacon—to embrace all human learning in depth. This being so, it is more important than ever to develop a wide-reaching view of essentials—to comprehend the interrelationships of the resource fields and the relationship of all to the public interest. This does not mean that we should relax our extension of the frontiers of knowledge. It does mean that not everyone has to become a specialist. The question is: How do we accomplish this? How do we give a broad education under the demanding pressure of specilaized knowledge?

Complaints of a too narrow education are frequently heard in the professions. Doctors, engineers, business executives, officers of the Armed Forces, all bemoan the fact that their education did not prepare them for the wide and complicated world. Our professional societies are aware of the problem and are trying to solve it. The Society of American Foresters is about to release a new study; the Range Society, the Soil Conservation Society, and the Wildlife Society are all examining the situation. So far, recommendations center around sending present graduates back to school and revising the curricula of those coming up. The Federal Government is financing advanced education for agency personnel through the Executive Training Act, and state governments are providing similar aid. In the universities new programs are springing up, from short courses to full graduate training.

All this activity sounds good, but what is it accomplishing? In some cases it is simply intensifying specialization. In others a broad approach to resource problems is being given. But the program as a whole lacks form. It is a sort of educational mushroom crop—growing fast, with some edible products, some poisonous, and some that just don't taste good. Problem awareness is the first step, of course, and with this awareness the same type of education that we have been giving is bound to do some good. But we need more than this. We need organized programs specifically designed to expand the intellectual range of the professional resource manager.

A few years ago I was chairman of the committee on professional training for the Soil Conservation Society of America. With the forbearance of the other committee members I will draw from the recommendations in our report. To my knowledge this report was never fully agreed upon or accepted.

We might be able to expand the area of perception by giving the student more training in resource fields other than his own. It is possible that knowledge of related fields would bring the understanding required to effect policies and implement programs for resource conservation. On the other hand, this wider understanding might be obtained by thorough study of the basic arts and sciences. The latter program would be directed at developing the capacity to generalize—to recognize social patterns through knowledge of their components. It would include learning a system of analysis based on recognition of both social and technical factors to aid in the definition and solution of multiple resource problems.

The first alternative—extension of resource training alone—actually increases specialization rather than broadening perspective. It leads to a proliferation of applied courses in which the student learns to use formulae and prescribed answers. The synthesis is made *for* him rather than presented as the key to the method of problem solving. Here, once again, our product is the technical specialist who "knows all the answers but doesn't understand the problem"—and furthermore doesn't even know how to go about analyzing the problem.

The second alternative—to which we subscribe—requires intensive work in the various independent departments and schools of the university together with courses or seminars in the methodology of problem analysis and solving. If we assume that conservation is not a subject matter field with its own body of knowledge or method of analysis but a way of interpreting the facts from the point of view of social goals, then we should study conservation by acquiring first the fundamental, traditional knowledge of society. We should develop our powers of communication through the study of language; we should increase our knowledge of human individuals and groups by studies in psychology, sociology, and political science. We should know the structure of social need through a rigorous training in economics and the structure of the natural world through work in the biological and physical sciences.

Relating these areas of knowledge to resource management: From the natural sciences comes realization of the possibilities and relationships of resources. How resources are used within these natural relationships is largely determined by the social sciences, and how this use is effectuated may depend on conceptual skills derived from the liberal arts. Resource management, in conservation terms, is a synthesis of this knowledge.

I have only time to sketch in the outlines of a program based on these ideas. At the graduate level it would be designed mainly for practicing administrators and staff technicians, although, of course, a student planning a career in resource management could come into it directly from his undergraudate studies. My personal belief is that this program is more valuable if the student has had a chance to be out and make a few mistakes in the field beforehand. The administrator or staff technician entering this program whose undergraduate education was in the natural sciences would need substantive knowledge in the social sciences—particularly economics and government, and the liberal arts—primarily English and literature, with possibly some advanced training in the biological processes. (For research scientists we would continue to emphasize intensive specialized study.)

Synthesis, the key to education in the field of resource administration, should be taught as separate subject matter in an integrating seminar. It is in the integrating course or seminar alone that conservation as such becomes a part of education. It is vital for the student to learn the methodology of synthesis and be able to use the process. It should not be done *for* him.

Problem solving as a process has meaning when it is observed in an actual situation. For this reason the case method is used as a means of teaching the process. Pothole drainage in an existing area is examined, for instance, from the standpoint of both landowner and public. Alternatives are weighed and balanced in terms of private and public goals, effects of existing policies are studied, the optimum solution is agreed upon, and recommendations are made to the individuals and agencies concerned. Let me emphasize that this process is all in relation to an actual situation which is itself in process. It is not ex post facto and it is not hypothetical.

The seminar can be approached from the standpoint of either social science or technology but the final result should be the same—training in the content and use of systematic, analytical methods of integration learned by the solving of real problems in resource use and development.

Such programs are already in effect but there are not enough of them. Perhaps the best known is at the university of Michigan. Other schools, including Montana, have started programs. There need to be many more, and the agencies should make better use of them.

The undergraduate program is more difficult. On one end of the spectrum, undergraduate education might be strictly a basic education. While sound, the student graduating from such a curriculum is usually not employable in a conservation activity. At the other extreme is the program using a minimum of substantive courses and consisting mainly of applied technical courses. Here the main objective is qualification for employment upon graduation. The student with the basic education would have a background for specialization but would need two or more additional years to become qualified. While there is no prejudice against the longer period of education it still appears desirable to hold it to four or five years. There should be, preferably, three years of education in the basic sciences and humanities and two years of specialization. This is not too different from some programs now in effect but I would like to include one strong integrating course or seminar such as that contained in the graduate program, where the methods of synthesis are taught as a process in resource administration.

I think we are at the threshold of instituting a nationwide program such as I have described. The more we study education in resource management, the more we become convinced that this will happen. There is no guarantee that our program will succeed in every case; a process of assimilation and integration is only as effective as the individuals it reaches and the use that they make of it. Our hope and our expectancy, however, lie in providing a structural basis for the capacities of those who are able, responsive, and concerned.

We are dealing with the living material on which human life depends; we cannot afford "elitist concepts" or prescribed "answers" based on insulation from humanity's true needs and desires. Only by offering an education as broad as the resource potential itself can we hope to honor the trust which society has placed in us—the management of our natural resources in the public interest. Resource managers—custodians of the trust—must know the meaning of public interest. Unless we help them to do so, society may place its trust elsewhere.

INFORMATION AND EDUCATION — BASE FOR CONSERVATION

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Information and Education has the key role in all conservation endeavors. The universality of this role gives wholeness or completeness to any conservation philosophy, principle, program, project or technique.

"The job of information and education at *all* levels is to build public understanding of man *in perspective*—man in a dynamic environment—man as a part of nature and subject to natural laws. Successful resource management will be an application of this understanding."[1]

"Building genuine public understanding" does not come about in a vacuum, but through people *communicating with each other,* as individuals or groups and through acceptance of goals.

Where can we find a "common frontier" of conservation as all-pervasive as that of information and education? What we do with information and education in the next decade, will have tremendous effects upon conservation efforts. We must break through the present boundaries of conservation I & E both quantitatively and qualitatively. The problems are no longer as simple as we once thought them to be.

Problems categorize conservation activities today. Some of the problems we deal with as conservationists involve "life" and "death."[2]

Problem solving in the development and use of natural resources is often by compromise or a matter of choice: someone has to convert possibilities into realities. During the process of making choices or policy we become involved with aesthetics, ecology, sociology, economics and politics. The same "factors" pervade action programs, but with the added conditions of skills of technicians and co-operating publics. All of these have—uniquely and peculiarly within themselves—information and education aspects which we must learn to identify and to use.

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[1]John A. Livingston. 1962. Discussant's remarks. Resources for Tomorrow, Proceedings of the Conference, Vol. 3, p. 293. The Queen's Printer, Ottawa, Canada.

[2]Many pollutants, including fallout and detergents, are toxic to living things; a wilderness or natural area once destroyed or disrupted cannot be restored to what it had been; many animals and their habitats have been extirpated; sacrifice (death) of some components of land and water accompanies drainage, damming, and widespread application of non-selective pesticides. A characteristic of what is described as "progress" is that losses of one kind are offset by gains of another.

AN EXAMPLE OF I & E FUNCTION

Early in the preparation of this paper, I had wanted to describe, as examples of how information and education functions, a number of resource-use problem cases discussed during the all-Canada Resources for Tomorrow Conference held in Montreal, October 23-28, 1961. Since the proceedings are available in published form, I shall use only one example which I have somewhat altered and condensed —namely, that of fisheries and water quality.

Inter-connected in this problem of fisheries and water quality are *land-use operations* (agriculture, pesticides, forestry, regional development and urbanization), *waste disposal* (mining, domestic water and industrial wastes), *power and irrigation dams,* and *transportation* (sea pollution, silt from new roads). There is, furthermore, enforcement of fisheries regulations and of water-quality standards. There is the cost of pollution controls and who would share it. Fish stocks and environment must be related. Fundamental and applied research of a wide variety must be processed and techniques developed and applied.

The total of the problem just cited is for a country to use its natural endowment so the *whole* community benefits—so most people possible can participate knowingly in some way or the other in the process of making choices. The social productivity must be enhanced, not impoverished.

Were it possible for us to examine in detail the intricacies of the fisheries and water quality problem, especially in light of information and education aspects, we would probably find that the I & E aspects are broadly reducible to those *inside* (directly bearing on) and *outside* (influencing) any given part of the problem. More detailed analysis would reveal a large variety of special interests to be served, with an over-all, co-relating goal of a successful and sustained fisheries and superior water quality.

Insofar as I can determine, there has never been a carefully presented I & E program for fisheries and water quality; or, for that matter, for any other current conservation problem. We do not know the *why, when* and *how* of the I & E function at all stages of a conservation problem multiplex. Therefore, when we meet new problems, the I & E involvements are predictable only in a very general way—we "play it by ear" or we "fight a fireman's battle".

These introductory observations, admittedly sketchy and too brief, should suffice to raise many questions.

SOME QUESTIONS ARE RAISED

Are I & E methods too narrowly construed?

Are I & E efforts brought into the picture belatedly?

I & E efforts to function properly, so it seems to me, must be considered intra- and extra-organizationally very early in the beginnings of any discussions involving problems, programs or projects.

Are the key decision makers sufficiently well-versed in the potentials of I & E involvement? If you are an administrator, a commissioner or a politician ask yourself when you last had an informative discussion with an I & E person? Do I & E persons know how to talk with decision makers? I am reminded here of how on many occasions it is the "outside prophet" or keen lobbyist who gets through with his message.

What are the methods most useful so that conservation-oriented I & E becomes conceptually functional? This is a tough question because our informational methods are still strongly couched in terms of putting out fires; and the strictly formal educational efforts are not yet widespread and well organized into tested conceptual process. However, excellent educational programs in conservation are underway, with the Ohio publication, " A Guide to Teaching Conservation in Ohio Elementary Schools," cited as an outstanding effort to conceptualize the material.

Can we measure those conservation agencies and organizations considered to be progressive or successful in problem solving and programs by the manner in which they apply the I & E function? How they apply it internally and externally?[3]

Do we have the answers to these and many other questions?

MORE RESEARCH IS NEEDED

It should be obvious that we do not have enough research underway in conservation I & E, in spite of excellent work of the Conservation Foundation, the Joint Council on Economic Education, Resources for the Future, Inc., the Conservation Education Association, the American Association for Conservation Information, the National Audubon Society, the National Wildlife Federation, the Outdoor Recreation Resources Review Commission, the International Union for Conservation and Protection of Nature, and several universities. Research efforts need to be stepped up and the field very much

[3]In 1962 and 1963, the Saskatchewan Department of Natural Resources conducted a series of in-service training courses of 3 to 4 weeks' duration for administrative and supervisory staff. I & E, although not included as a stated subject, nevertheless received some discussion. One term paper was directed to the re-organization of I & E work within the department. The I & E function is still construed by most members of the department to be largely that of news releases and preparation of publications—primarily service functions.

needs a central abstracting service similar to that being performed by *Wildlife Review* for wildlife management. One cannot, of course, overlook the excellent I & E efforts of professional resources-management organizations—particularly those involving ecology, forestry, wildlife, fisheries and soil and water. The publications of the professional groups are the "lodestone" of the I & E workers.

More research is needed because it has become most apparent that the making of responsible conservation choices is difficult and complex. Emotional, political, economic, social, ethical, religious, aesthetic and ecologic qualities (values) weight any given problem.

The current great debate on pesticides contains all the "value" ingredients just mentioned, with the public caught in a cross-fire of "propaganda" and "informational" efforts. In this instance, it would probably be "occupational-suicide" for some I & E persons, especially those in governmental agencies, to try to get at basic truths and express these to the public through normal channels.[4]

I have followed, as you have too, some of this great pesticide debate and observed the protagonists. It seems to me that those *not* directly connected with agricultural and chemical industry fields are demonstrating more humility and compassion and a desire for more rigorous research. If this is so, why? Is there really an "ecological conscience" that can be nurtured?

To overcome short-comings that tend to make us react somewhat inhumanely in making great decisions, there is need to (1) *more effectively organize and dispense present knowledge;* and (2) *more effectively organize the many fields which impinge on or are strongly involved in conservation planning or activities so that the best (truthful) and fundamental knowledge of the time can be more quickly disseminated and absorbed.*

We also need, especially in I & E work and positions, to discover whether or not we are attributing certain beliefs to others out of sheer ignorance. We must become more versed and skilled in the "talking common sense" methods being developed by general semanticists.[5]

These three great needs—organization of knowledge, co-ordination of endeavors and learning how to talk with each other—are being investigated in many places and in many ways, especially in the great centers of higher learning where freedom of thought and expression is still espoused. Institutes of higher learning must guard

[4]A news item (New York (AP), Feb. 21, 1963) stated the formation of a "Scientific Institute for Public Information" to provide the public with information on such scientific problems as radioactive fallout, pesticides, air pollution and detergents in water. Among the 21 founders were Edward Tatum, a Nobel Prize winner, and Theodore Dobzhansky, both geneticists, microbiologist, Rene Dubos, and anthropologist, Margaret Mead.

[5]See published works of Irving Lee, S. I. Hayakawa, Wendell Johnson, etc.

against in-growth and avoid, like the plague, any development of "obligation" to sources of funds—funds should be free of containments that could stifle freedom of research and reporting.

Another pertinent question we must ask today is: *What is being promoted or accomplished along these lines by agencies and organizations directly concerned with conservation?* Who and where are some "key" groups which can take hold of exploring these needs and extend the findings so that we might get on better with this task of building *genuine* public understanding of conservation?[6]

HOW DOES AN UNDERSTANDING OF THE I & E FUNCTION GROW?

Each of us has over the years become familiar with or aware of outstanding examples of I & E work in the field of conservation. Some are awarded formal recognition by such organizations as A.A.C.I. and the Wildlife Society. I have selected a few examples, with some annotation, to illustrate some of the ways in which an understanding of the I & E function grows. You will think of many other and better examples.

Example 1:

First of all, let me recommend to you for careful study the three volumes and supplementary publications of the all-Canada "Resources for Tomorrow" Conference, with particular emphasis on Vol. 3, *Proceedings of the Conference*, and the I & E background paper, "Renewable Resources Information and Education in Canada" by D. F. Symington in Vol. 2. The reports of two Information-Education workshops (pp. 287-298) and a statement on I & E by Research Co-ordinator D. F. Symington (pp. 497-500) are included in Vol. 3 and represent some splendid discussions relative to information and education.[7]

These publications lack indexes, but I did make a partial listing of remarks bearing pertinently on I & E in the proceedings volume (Vol. 3) and found well over 100. Many of the statements were in the nature of preliminary and general recognition that I and E efforts must be increased or be more vigorous.

Because many of you have not had an opportunity to study these Canadian publications, it seems worthwhile here to state the seven

[6]In answering this question, one must certainly include the forum afforded by the North American Wildlife and Natural Resources Conference. From 1941 on to the present there have been some 140 stated I & E papers and discussion which if gathered together into one book would make up about 1050 pages. Also see footnote 4.

[7]Resources for Tomorrow Conference. *Conference background papers.* Vols. 1 and 2 (1961); *Proceedings of the conference.* Vol. 3. (1962); Supplementary volume of *Conference background papers* (1962); and *Guide to benefit-cost analysis* (1962). Queen's Printer, Ottawa, Canada.

assumptions which were derived jointly by the two I & E workshop sessions of the conference. The assumptions are:

1. The I and E function is indispensable to the proper concept of management of renewable resources. Only by associating this function with policy making can the citizens and responsible organizations participate in effective management of resources.
2. The I and E function must be understood by administrators in general, and it must be carried out by individuals with a knowledge of and preferably training in the social sciences and humanities, and with, as well, a grasp of the problems of resource management.
3. Effective resource management requires a change in the attitudes and behavior, with regard to renewable resources, on the part of the people of Canada. Existing agencies of information and education must be strengthened and other agencies and methods must be created.
4. Means must be provided to assist the existing I & E agencies in bringing about the required changes in attitude and behavior. An agency or agencies must be created to provide clearing-house and co-ordination functions with respect to this concept. This includes the provision of workshops and meetings for leaders in formal education, the mass media, and industry.
5. All avenues must be exploited for the communication of technical information regarding the use of renewable resources.
6. The modern concept of resource management requires some changes in the present organization of I and E facilities in Canada. It requires:
(a) New organizational structures developed according to experience with agricultural and other well-developed forms of extension;
(b) Facilities for the study of communication processes; the development of methods for assessing change in public opinion in specific cases;
(c) The development of standards, criteria, and training procedures for I & E personnel associated with resources agencies.
7. Any concept of a National Resources Council must include means for the study and support of the I and E function.

There were reservations concerning Assumption No. 5, with one Education Workshop not accepting it, otherwise there was general agreement in principle to the others.

Example 2:

The organization and methods of the Conservation Council of Ontario and the Montana Conservation Council, Inc. are worthy of full-session discussion. Both are examples of non-political, citizen organizations, bringing together private organizations and government agencies. Both include the objective of public information and education on renewable resources. The Montana group has been quite vigorous in discussing ways and means of improving education requisites of civil service employees in government agencies concerned with natural resources. The Ontario Council has developed a method of information flow *to* and *from* governments, and the public is represented on the council by 17 renewable resources organizations. Recommendations considered by the Ontario group are not passed on to the government unless they are considered compatible with the over-all requirements for resources development in the interest of the province and its people.

Example 3:

The "keynote" address of the 1962 annual meeting of the Nature Conservancy made by President Alexander B. Adams is rather unique. It was published in the Fall, 1962, issue of ***The Nature Conservancy News.*** Mr. Adams' description of re-directed involvements for conservationists and the need for more diversified talents—particularly those of lawyers and accountants—to aid in the work of conservation organizations is refreshing. Mr. Adams' talk deserves widespread reprinting by conservation periodicals across North America.

Example 4:

For another eye-opener, I direct your attention to the 1962 "Annual Report of the Conservation Committee" of the Wilson Ornithological Society (see ***Wilson Bulletin,*** June, 1962, pp. 205-224). This excellent report, by Dr. Thomas G. Scott and committee, objectively and reliably covers conservation education, land-use problems, habitat pollution, control of bird populations, and endangered species. Literature cited includes 37 items. Reports such as this one are of top value to I & E workers who must, of necessity, try to keep up on a large flow of information.

Example 5:

The W.O.S. report mentions the Biological Sciences Curriculum Study of the American Institute of Biological Sciences, with emphasis on the "Green Version" (ecological approach) which has been headed up by Dr. Marston Bates of the University of Michigan. These new BSCS high school biology texts, especially the "Green Version," will have tremendous educational impact of conservation import across the continent.[8]

[8]An advertisement of these texts appears in the February 16, 1963 issue of the *Saturday Review*. For more information write to BSCS, University of Colorado, Boulder.

Example 6:

I & E workers will wish to examine a publication issued recently by the Committee on National Resources of the National Academy of Sciences, Washington, D. C. This N.A.S. Publication No. 1000 is entitled, "National Resources: A Summary Report to the President of the U.S.A." I picked up a lead on this publication from the February 2, 1963 issue of the *Saturday Review* which carried a one-page summary commencing with these two paragraphs which are of particular pertinence to conservation I & E:

"Perhaps the most critical and most often ignored resource is man's total environment. Increasing awareness of the importance of understanding the balances of nature is reflected in the gradual development of interest in ecological studies. The study of the interaction of all biologic species, among themselves and with the inanimate forces of nature, requires co-ordination of the contributions of all the sciences, natural and social.

"The wisdom of examining environment in the totality of its interaction with man becomes increasingly apparent in view of the rapidity of environmental change in our country. We live in a period of social and technological revolution, in which man's ability to manipulate the processes of nature for his own economic and social purposes is increasing at a rate which his forebears would find frightening."

Other problems, of a "life" and "death" nature, listed in the National Academy of Sciences publication, involve: Environmental Health and Disease; Geographic and Time Distribution of Disease; the Environment and Biological Functioning; and Climatic Modifications. The *Saturday Review* item closed with this excerpt from the N.A.S. report:

"In summary, it is apparent that man must concern himself with a variety of changes in the environment, both those caused by human beings and those reflecting man's responses. Some are good; some may be very harmful. That we often do not have any clearcut idea of their impact on man, or of man's response, is cause for concern. It would seem unwise to continue to tamper with environment without, concurrently, striving to determine the real and lasting effects of our actions."

All conservationists, especially those in education, should get a lift in spirit from this N.A.S. publication because of its emphasis on "ecology"—it is a great leap forward. Of equal interest is that a "humanities" periodical, the *Saturday Review,* has for several years now contained monthly a most enlightened science section. Witness also the impact of the pre-publication exerpts from Rachel Carson's book, *Silent Spring,* which appeared in another humanities periodical, *The New Yorker.* These magazines reach many readers who do not belong to conservation groups and they make conservation-minded readers do a "double take."

Example 7:

The problems and philosophy of conservation are being espoused by an ever-increasing number of leaders of the humanities, such as Lewis Mumford and Alan W. Watts. Conservationists should search out the writings of these thinkers. Here are philosophers who are coördinating, refining, and re-interpreting knowledge and goals dealing with or basic to the humanities of "environmental conservation."[9]

INTERPRETATION HAS MUCH TO OFFER

One of the newer, younger giants that has entered conservation I & E is *Interpretation.* There is even a new organization—Association of Interpretive Naturalists, started in 1962—which holds an annual workshop and publishes a newsletter.[10]

Conservation agencies and organizations are increasingly aware of stating to the public conservation goals and problems and are doing this rather well through all media.

Many of the goals, as well as problems, are quite readily verifiable at first-hand as environmental realities: wetlands for waterfowl, tree farms, self-perpetuating and well-stocked forests, non-eroding and fertility-renewing farms and ranches, natural areas saved, a flock of prairie chickens, a trout stream, a healthy watershed, a city that does not lead to rebellion against one's environment, new parks, clean and usable water, food free of pesticide residues. These are tangibles that people can experience—these are products of conservation. They are "good" products and should be so advertised. They lend themselves readily to interpretation.

Conservation departments are in a sense "entrenched companies" selling the wares of renewable natural resources. They must, in the words of advertising men, "defend their brands of production." This cannot be done by words alone, there must be improvements in the products; and (this is something the advertising men usually don't emphasize), there must be *improvements in our uses.* Perpetually

[9]For starters see *The Human Prospect* by Lewis Mumford (The Beacon Press, Boston, 1955); *This Is It, Nature Man and Woman,* and *The Wisdom of Insecurity* by Alan W. Watts (1958, 1958, 1951, Pantheon Books, Inc., New York, respectively); and *Life Against Death* by H. O. Brown (1959, Wesleyan University Press, Middleton, Connecticut).

[10]For information on the A.I.N. write to John D. Kason, Cleveland Metropolitan Park District, 2048 Standard Building, Cleveland 13, Ohio. For background reading see the following books by Freeman Tilden: *Interpreting Our Heritage* (The University of North Carolina Press, 1957) and *The State Parks: Their Meaning in American Life* (Alfred A. Knopf. Inc. 1962).

the end result should be better products and better uses. The public is the buyer and will determine how well it wishes to support conservation efforts.[11]

Lead the public to the products *in the field* and give these products vigorous interpretation.

All conservation agencies and organizations, conducting any kind of interpretive programs in parks or elsewhere, should strongly support the efforts of such groups as the Association of Interpretive Naturalists and send working representatives regularly to its workshops. Similar support should be given to the Conservation Education Association and the American Association for Conservation Information.[12] These are dynamic organizations opening up new vistas of I & E. Their results, furthermore, are quickly absorbed into outdoor education and school camping.

IN CORRELATION AND SUMMARY

For much telling of the conservation story to the public, we must continue to rely on I & E specialists. However, I & E budgets are still considered expendable when the chips are down. I & E workers are generally too few in numbers and low on the totem pole and underpaid. They are usually given no authorized policy-making responsibilities. They are usually called in as an after-thought and expected to perform miracles in building genuine public understanding or to act as firemen. There is drastic need in most provinces and states for conservation educators on a provincial or state level, *devoting full-time* to aiding schools and teachers in conservation.

I & E workers, in reality, should be among the best trained and best paid on a staff. They should be in close and constant consultative touch with the top echelon of administration. They also need to have their feet on the ground and be understanding of and acceptable to field men and classroom teachers. I & E efforts are of a creative nature and I & E workers should have ample "freedom of time." Working quarters should be conducive to creative efforts.

The major point I have made and tried to illustrate is that the information and education function must pervade all members and programs of any conservation agency or organizations. If given proper encouragement, this function can grow, but it needs research.

Information and education are surely the base for conservation.

[11]There are many excellent publications dealing with advertising, but one that I have found stimulating and applicable to conservation I & E is *Reality in Advertising* by Rosser Reeves. Alfred A. Knopf, Inc., New York, 1961.

[12]C.E.A.—Oliver C. Sand, Secretary, 17715 Westview Drive, New Berlin, Wisconsin. A.A.C.I.—Bryant Chaplin, Secretary, Massachusetts Division of Fisheries and Game, Westboro, Massachusetts.

We do not get along without communicating or learning. May we always be reminded that "man lives . . . *at the level of the ideas of his time*."[13]

DISCUSSION

DISCUSSION LEADER VESSEY: Very good, Doug, and no truer words were said than when you expressed the opinion that I and E and I and E techniques are involved in almost everything that goes on in the conservation field. Success or failure depends on the preventive and constructive I and E work. I will ask the first volunteer to expand on Doug's remarks.

MR. PERRY: I am a wildlife technician, and I am very gratified to see the technicians here, and it seems to me that this session here is probably one of the most vital sessions we can have at this conference. As a wildlife technician, I am realizing more and more the importance of information and education in a conservation program. We technicians live in an ivory tower. We are not concerned with getting information across to the public. Without getting information across to the public, I think our cause is lost.

MR. VESSEY: Thank you for those profound words. Do you want to talk to that, Doug, or add to it if you wish?

MR. WADE: I can't add to it.

MISS JUANITA MAHAFFEY: I am with the Division of Water Supply and Pollution Control in the U. S. Public Health Service, Washington, D. C. I have one priceless story that I must tell this group. This occurred before I came here. In our program, we have a federal aid that goes to the State Water Pollution Control Agencies, and it functions in somewhat the same manner as other agencies of the Federal Government. The lady who is in charge of keeping track of what the states do with these funds in the various stages of the program came to me with a story that I think must be told here. Each state is required to give an accounting, of course, of what it does with its funds, and one of the states had sent in this report: During the past year it had hired three professional people in the persons of three sanitary engineers, two sub-professions, one an information writer, and one a janitor. I think this speaks for itself in what some of the state agencies need not necessarily apply to water pollution control alone. They are categorizing their information people. I just had to tell this.

MR. VESSEY: Do you want to comment on that, Doug?

MR. WADE: Well, I think she has made the point. The usual expendable part of most departments and agencies unfortunately is the I and E part, and whenever budgets are cut or need to be cut, whenever staffs have to be unloaded, it is usually the I and E that gets the first ax, and just look through your own department, your own agency, and see if that isn't true. There are a couple remarks here, since they have given me the floor again, that I would like to make. In regard to our great pesticide debate, and I think this is wonderful that we are having this debate, I have picked up a news item which was an AP release from New York City on February 21st, and it stated that the formation of a scientist institute for public information was going forward with the intention of providing the public with information on such scientific problems as radioactive fallout, pesticides, air pollution, and detergents in water. Among the 21 founders were Edward Tatum, a Nobel prize winner, and Theodore Dobzhansky, both geneticists, microbiologist Rene Dubos, and anthropologist Margaret Mead. Now, obviously, we, in our own conservation agencies, are not being able to do the job in order to deal with the controversial topics. It is occupational suicide, believe me, I know, to attack the problems that are debatable or that are somewhat black and white in the minds of the public or in the minds of the organization or agency. You cannot get up there and give both sides. Now, this is critical, and until our

[13]Ortega y Gasset. 1944. *Mission of the University*, p. 57. Princeton University Press, Princeton, New Jersey.

administrators, our policy makers, and our political leaders get themselves into the proper frame of mind, the one that I call talking common sense, we are not going to be able to do an adequate job in presenting some of these controversial topics.

MR. VESSEY: One of our panel members wants to present a question. Dwight?

MR. RETTIE: This is only half a question and half a statement. Doug has, I think, touched on one of the really difficult problems of I and E programs when he mentioned the criteria by which you attempt to measure the effectiveness of an I and E program, and here I submit the I and E people themselves have done a totally inadequate job of assisting their own administrators and assisting themselves in providing the means and mechanisms of measuring an effective I and E program. How is an I and E program commonly measured? How is its effectiveness commonly measured? Well, I submit pretty largely by most administrators it is measured by lack of mail they get. It is measured by how few people get excited about something. It is measured by how few telephone calls they get from members of congress, and all of these measures may, in fact, be not the measures of an effective I and E program, but precisely the reverse. They may, in fact, be the measures of an ineffective I and E program. I think that the I and E people themselves need to take a long hard look at this subject and need to set their own standards of the measure of its effectiveness, standards that see the problem in the necessary long run perspective, and problems and criteria that also recognize the fact that every I and E effort doesn't come out quite like the I and E specialist tries to sell it. Thank you.

MR. WADE: Just one comment here. Research is needed. The I and E fellow is so obsessed with the immediate day to day problems that he cannot cope with this matter of evaluation. This is going to take the accumulated and concerted efforts of some of the great universities and so on. We ought to be pouring millions of dollars into this research on the I and E function and to cover this matter of evaluation. We are putting picayunish little cents into it, not the millions that are needed at the present time. We need to call on the best skilled top men in the country to get at this research.

THE NEED FOR HISTORIC PERSPECTIVE IN CONSERVATION

CHARLES H. CALLISON
National Audubon Society, New York City

He who considers things in their growth and origin will obtain the clearest view of them.—Aristotle

In conversations with younger men in wildlife management I have frequently been struck by how little they know about the origins of the agencies or organizations for whom they work, and even how little they know about the beginning and growth of their own profession. Last summer, for example, I met a young biologist employed by the California Game and Fish Department. I was astonished to discover that while this young man was acquainted with Starker Leopold, having studied at Berkeley, the name of Aldo Leopold meant nothing to him. He knew nothing about the Conservation Foundation of New York City and did not know of Fairfield Osborn. A particularly uninformed question about the policies of the National Audubon Society prompted me to ask him if he had read the autobiography of T. Gilbert Pearson.

"No," he replied. "Who was T. Gilbert Pearson?"

The fact that this young man was a fisheries biologist does not excuse his ignorance of the great names and works of the past in wildlife conservation. It does illustrate, in my mind, the shortcomings inherent in narrow specialization.

More recently I talked with a mammalogist whose studies in the Arctic have distinguished him. He agreed that pending a determination of how many polar bears there are and how much hunting pressure the species can stand, it surely would be the course of common sense to clamp down on the current exploitation of the species by the commercial airlines and the tourist industry. The problem is an international one. Asked how he would suggest bringing about the needed controls, he proposed organizing a symposium of scientists. This would indeed be a sound approach to the scientific problem; but the point is, for the purposes of this paper, the mammologist did not understand that the only feasible way to bring about stop-gap controls is through political channels, not through scientific circles.

When the opportunity appeared four months ago to take part in this panel, the inadequacy of the modern biologist in historic background was on my mind. I proposed to survey the courses of study in colleges offering degrees in wildlife management to see if I could pin down evidence of shortcomings in the teaching of history. The problem, of course, is broader than that. The problem is how to give the wildlife student some inoculations that will take, not only of history but also of political science and philosophy as *related to the objectives and practice of wildlife management.*

Countless times we have heard the assertion that in practice the management of wildlife is nine-tenths the management of people. This is a truism. Sometimes it is phrased this way: "Conservation is 90 per cent education." But unfortunately our future resource managers and administrators are coming out of college with but the dimmest of concepts about the political, social and economic forces that shape the behavior of man toward his environment.

Now and then our wildlife schools produce a scientist. Mostly they are turning out technicians, technicians that increasingly show the tendencies toward introversion and tunnel-vision that we have criticized in civil engineers, commodity foresters, control entomologists, and others of narrow specialization.

If this deficiency, this tendency toward introversion, can be corrected, it will help the biologist understand that the Federal or State agency that employs him is a political institution, and that it is as dependent for its sustenance on public opinion and political action as it was for its conception and birth. (When I speak of *politics* in this paper I use the word in its original and wholesome sense, the ways and means by which people contrive to govern themselves in a free society. When I speak of politics in the Democratic vs. Republican sense, I shall use the adjective *partisan* or the noun *partisanship.*)

Correcting the deficiency will help the biologist understand that to treat wildlife as if it were a commodity resource, is to lose sight of the fact that esthetic appreciation was the basis of the public interest that created the laws and agencies through which wildlife programs are carried out. The public motivation was not value judgments based on dollars and cents. With few individual exceptions, the sportsmen of today as of yesterday do not look upon game or game fish as commodity resources. They do not back your programs to maintain the arms and ammunition industries, nor to create prosperity for the sporting goods dealer. I remember how the late Dr. Rudolf Bennitt of the University of Missouri used to argue wth convincing logic that quail hunting was essentially an exercise in esthetic appreciation: the derivation of esthetic pleasure in the burst of the covey, the flight of the birds, the autumn setting in nature, the work of the dogs, the skillful handling of gun. I believe Dr. Bennitt was right, and that policies that seemed based on the idea that the purpose of quail management is merely to provide more birds per gunner is missing a basic truth, and is likely to lose its public.

It would help the fine but frustrated technicians of the New York Conservation Department understand why the great majority of New York's citizens, and most of its sportsmen, would rather have fewer deer in the Adirondacks than to permit the Department to do habitat improvement at the risk of opening the State Forest Reserve to logging and road-building.

It would help present and future biologists and administrators realize that the civil-service freedom from partisanship that you treasure was achieved only through political action, and that it will be preserved only through political action—by the playing of Democrats against Republicans (or faction against faction in the one-party states) with citizen conservationists holding the balance of power.

And if they knew history, many of the protagonists in the modern debate between the so-called "users" and the so-called "preservationists" would be considerably mellowed. It helps to know that exactly the same argument in almost the same terms was carried on a half-century ago, with Gifford Pinchot as the spiritual leader of the "utilitarian school," and the founders of the National Park system arrayed on the other side. A knowledge of subsequent events helps one realize that the people need and intend to have both kinds of areas—those cropped for commodities and those kept for their scenic and esthetic values—and that there is room in America for both.

A few weeks ago I attended a State legislative hearing in Maine on a pesticides control bill. I was not surprised by the organized display of opposition by farm groups for whom the State Commissioner of Agriculture was the leading spokesman. But frankly I was shocked that no one showed up for the Department of Game and Inland Fisheries. I do not believe this would happen in a state whose wildlife officials were properly sensitive to the realities of political life.

When I set out to review the courses of study in our wildlife management schools for this paper, I quickly realized that in the time at hand the best I could do would be in the nature of a preliminary survey. To do the job thoroughly I should need to examine the course material in detail, including the content of the lectures. I selected as a representative sample the institutions that have Cooperative Wildlife Research Units and sent them a letter of inquiry (copy attached). The list I worked from did not have some of the Coop Units more recently established. I wish to thank the Unit leaders or other University officials who sent me copies of curriculums, course outlines, and other material from the following: University of Alaska, Auburn University in Alabama, University of Arizona, Colorado State University, University of Idaho, Iowa State University, University of Maine, University of Massichusetts, University of Missouri, Montana State University, Oklahoma State University, Ohio State University, Utah State University, and Virginia Polytechnic Institute, Recognizing the limitations of the quick survey I was able to make, I offer the following observations:

Most of the leaders or department heads presented the titles of texts in their more general courses as evidence of such historic material as the students are exposed to. The texts most commonly listed were Aldo Leopold's *Game Management* and Durward Allen's *Our Wildlife Legacy*. Others included Huberty, Martin R. and Warren L. Flock, *Natural Resources,* McGraw-Hill, N.Y.: Leonard W. Wing, *Wildlife Conservation,* Wiley, N. Y.; Ralph and Mildred Buschsbaum, *Basic Ecology,* Boxwood Press, Pittsburgh, Pa.; and Shirley W. Allen, *Conserving Natural Resources,* McGraw-Hill, N. Y. The outside reading most commonly listed was Leopold's *Sand County Almanac.* No one could quarrel with these selections but the historic material in them is limited.

Recommended readings or references listed with the few detailed course outlines I got to see included selections from periodicals and technical journals, some pamphlets, and the newsletters or bulletins issued by such organizations as the Wildlife Management Institute, Sport Fishing Institute and National Wildlife Federation. While this material typically includes some philosophic or point-of-view discussions and gives some insight into the legislative and administrative processes, it contains little of genuinely historical nature.

The curriculums required of undergraduates majoring in wildlife or fisheries biology (or management) seem at first glance to allow the student more or less lessway in electives. But at second glance one discovers that all but a smattering of electives must be chosen from courses in the student's particular field of specialization, in mathematics, or in related sciences.

The curriculum which the wildlife student is told he *must* follow typically requires freshmen English, and perhaps a second-year course in either English composition or literature. In addition the wildlife schools, without exception I believe, require a course in public speaking and or technical writing. The need for communicative skills has gotten through.

The science student in most universities is required to take one or two courses in history or political science or sociology during his first two years, and perhaps a basic course in philosophy. But once past his sophomore year, the science student has little opportunity to delve into political science or the humanities, despite the lip service given this goal in the literature of many universities.

Graduate study, of course, is typically concentration in the student's field of specialization.

In the following excerpts from letters written me by Department heads or Unit leaders, I have tried to omit anything that would identify the institution. What seems an admission of shortcoming by some may indicate an honest attitude of self criticism, but may not provide a fair basis for comparison with another who admitted no failure. My own survey was so cursory that any comparison between Universities that I might make or imply could be unfair; however, the observations I have given are, I believe, valid as generalizations.

"Our students are considerably less well-grounded in conservation history of public land management than are most forestry students, if my own experience (at a named University) is any yardstick," one said.

Another wrote: "I would be the first to agree that at this university we do not teach sufficient grounding in the history of natural resources and public land management. We can, however, include more than many colleges because of the flexibility of our program and lack of specifically required wildlife courses in big game, waterfowl, furbeareres, etc., for an entire semester."

"Relative to required outside reading," one Unit leader commented, "there seems to be little of this in the department. In fact, I can find no one that requires outside reading. Reference lists, of course, are commonly furnished the students in advanced courses."

Another said, "We have no specific course covering the history of natural resources, public land management and conservation in the United States, although I have emphasized some historical aspects in various courses, particularly in Principles of Wildlife Management."

From another thoughtful Unit leader: "Natural resource history and management are areas where the .... University curriculum might be weak. Offsetting this weakness, if such it is, is the strong orientation toward basic ecology, which is developed through our curriculum."

And from a Department head: "Within our Forest, Range and Wildlife College, we also have several conservation courses in which one gets some idea of historical development. .... gives a land use seminar in which a speaker from each of the agencies as well as representatives from the livestock groups discuss the problems of their area. .... gives a course in public land administration in which a student gets some historical perspective. None of these, however, are required, and few of our students take them.

In moments of self examination the wildlife profession has shown an awareness of the dangers of technical specialization. A report of the 1958-59 Employment Committee of the Wildlife Society on the Training and Employment of Wildlife Biologists (published in Journal of Wildlife Management, Vol. 25, No. 2, April, 1961) noted a deficiency in the communicative skills which, the Committee said, "appears to be the result of over-emphasis on technical subjects at the expense of English, speech, literature, etc. A *broad* (italics mine—C.H.C.) liberal arts approach at the undergraduate level would help correct the situation." The Committee also said, "People are usually an important part of the biological problem on which he works. If the biologist is not a 'born psychologist,' a *broad* familiarity with history, literature, psychology, philosophy, etc., is a help."

In a summary of the training requirements for wildlife biologists, the Committee listed as one of three recommended areas of concentration: "*Broad* exposure to liberal arts subjects with special attention to languages and speech.

In addition to agreeing with the Society's committee, I was interested in the repetition of the adjective *broad.* What does it mean? In view of the strictures of the modern technical school, how is the student expected to achieve his *broad* familiarity with history, literature, psychology, philosophy, etc. By walking past the University library on his way to zoology lab? Or can he become *broadly* exposed by dating a girl majoring in the liberal arts? Joking aside, he probably would learn more from the girl than from the liberal arts courses he can squeeze into his wildlife curriculum.

What I found out from the material so helpfully sent me does, I believe, support my thesis that the wildlife biologist is coming out of college with little background in the history of the resources he will be helping to manage or of the agencies and organizations he will be working for and with. His background is equally deficient, I think, in political science and in an understanding of the social and economic needs and the currents of philosophic thought that have shaped our customs, our attitudes, our institutions and our laws affecting natural resources. There is grave danger, I believe, that the profession of wildlife management may be slipping into the same weaknesses that we have observed with dismay in other technologies of our times. These are the weaknesses produced by mental inbreeding. How can we avoid them?

In all realism there seems little likelihood of opening the undergraduate curriculum or relaxing the graduate regimen to permit the wildlife student to take numbers of courses in history and the humanities. Competition within the profession and the needs of employers require a high degree of technical proficiency. Moreover, the student is supposed to learn English and get on speaking terms with history in high school. He also is required to study the forms and processes of American government at the secondary level. He can study these same subjects in greater depth in the regular college courses—and he should take all of them he can squeeze in—but in none is he likely to find a text or a teacher that knows how to relate conservation to the orthodox treatments of world history, American history, political science or philosophy. But such relating can be found in books written by and about the leading thinkers and doers in the conservation field.

I suggest the wildlife student can be truly broadened and better equipped to deal with the problems he will encounter in politics and public relations through the required reading of selected books, coupled with a seminar that will include discussion of the readings; lectures by administrators and legislators; talks by, or question-and-answer sessions with, the leaders and lobbyists of the special interest groups; visits to legislative sessions and hearings; and attendance at the meetings of resource-related organizations. The readings and the seminar I suggest should be a continuing experience through the junior and senior years. They could well extend into the graduate program. Out of them could grow interest and habits of mind that will carry on through life.

What kind of books? There are dozens that could be advantageously used. I will offer a few suggestions, and I have attached copies of letters from Arthur H. Carhart and Seth Gordon, two of our history-conscious professionals, who at my invitation contributed suggested lists.

The readings should by all means include books by and about the great conservation leaders of the past, men like Gifford Pinchot, Stephen T. Mather, T. Gilbert Pearson and Hugh H. Bennett. Books by leading thinkers who interpreted, and set the pace for, the developing public attitudes toward the land and its living resources, men like Henry David Thoreau, George Perkins Marsh, John Muir and Aldo Leopold. Art Carhart recommends Izaak Walton's *Compleat Angler* and the nature-oriented psalms of the Old Testament as starting points, and I would concur.

Autobiographies are invaluable for the insights they provide into the interplay of personalities, and because by personalizing history they make the subject fascinating.

The list should be all means include the great trilogy on the exploration and settlement of the continent by Bernard DeVoto and DeVoto's conservation essays that appeared in *Harper's Magazine.*

Here was one of America's finest social historians who was ever conscious of the land and its resources. The best of the DeVoto essays can be found in a volume called *The Easy Chair* that was published by Houghton-Mifflin about the time of the writer's death.

I would strongly recommend James Trefethen's *Crusade for Wildlife,* and every resource manager and lay conservationist should be required to read *Politics and Grass,* the recent and illuminating study by Phillip O. Foss of the administration of grazing on the public domain.

My list of recommended books is attached, as are the lists suggested by Mr. Carhart and Mr. Gordon. There is no complete or perfect list; the readings should be as open-ended as the seminar discussions that accompany them.

BOOKS RECOMMENDED BY MR. CALLISON

Carhart, Arthur H. *Water—Or Your Life,* Lippincott, N. Y. 1951.

DeVoto, Bernard. His trilogy: *Across the Wide Missouri; The Course of Empire,* 1952; *The Year of Decision,* 1942.

DeVoto, Bernard. *The Easy Chair.* Selections from Harper's Magazine, particularly those under Part V. "Treatise on a function of Journalism." Houghton Mifflin, Boston, 1955.

Greeley, William B. *Forests and Men.* Doubleday, Garden City, N. Y. 1951.

Huth, Hans. *Nature and the American.* University of California Press, Berkeley. 1957.

Ise, John. *Our National Park Policy, A Critical History.* Johns Hopkins Press, Baltimore, 1961.

Krutch, Joseph W. *Henry David Thoreau,* Sloan Associates, NY 1948.

Leopold, Aldo. *Sand County Almanac,* and *Round River.* Oxford University Press.

Marsh, George Perkins. *The Earth as Modified by Human Action,* Revised edition of *Man and Nature,* New York, 1874.

Pearson, T. Gilbert. *Adventures in Bird Protection,* D. Appleton Century Company, New York, 1937.

Peattie, Donald Culross. *Audubon's America.* Houghton-Mifflin, 1940.

Pinchot, Gifford. *Breaking New Ground,* Harcourt, Brace, N. Y., 1947.

Shankland, Robert. *Steve Mather of the National Parks,* Alfred A. Knopf, N.Y., 1951.

Stegner, Wallace F. *Beyond the Hundredth Meridian: John Wesley Powell and the Second Opening of the West.* Houghton Mifflin, Boston, 1954.

Trefethen, James B. *Crusade for Wildlife.* The Stackpole Co., Harrisburg, Pa., 1961.

THE PUBLIC LIBRARY, THE CITY AND COUNTY OF DENVER
1357 Broadway, Denver 3, Colorado

January 30, 1963

Mr. Charles H. Callison
Assistant to the President
National Audubon Society
1130 Fifth Avenue
New York 28, New York

Dear Charlie:

Your letter of January 18 caught up with me at Carlsbad, New Mexico. For that reason I am somewhat removed from the reference material I might have at the Conservation Library Center, but I'll give you what I can from this point.

As a basic consideration, I have a sharp feeling that most of the Wildlife Management boys get into biology too fast and do not have enough foundation work to give them breadth of vision and outlook. There are two types of books that I believe should be required reading for background and perspective. The first group deals with philosophy. The most important value that lies in this group of books is the establishment of the relationship of the human being to the complex that he is a part of. I don't know what is the best sort of book to achieve this end, but I would list in the first place The Compleat Angler by Mr. Walton. Quite different, but in another phase of this same approach to the relationship of the human being of the outdoors are the hunting tales that were written by Theodore Roosevelt. If you want to look at the King James version, you'll find the Bible has a very considerable portion of the books such as the Psalms dealing with man's relationship to what God created. In explanation, Charlie, if that be needed, I believe there is too much stuffing of the average student with facts and theories and not enough of examination of the relationship of the species of which we are part to all the other species of the complex living world.

If you get a chance to talk to Joe Penfold, I believe you will find one of the most illuminating discussions in this particular sector of natural resource management that you could encounter. I hope you get this chance before you finish up your paper.

The other portion of the books that I would list deals with the fundamental resources that underwrite wildlife management. As a starter, Charlie, dig out the conservation library file that we sent Carl Buchheister. In it you will find the discussion of criteria to guide us with regard to the development of the Conservation Library Center. In that you will find that I have suggested that interests lie in zones starting with the most fundamental: soil, water, and the green things that these two primaries, plus atmosphere, plus sunshine, produce. I would try, therefore, to suggest a primary book in water and its relationship to the whole complex of living things; another on soil, and perhaps books that deal with forestry or soil conservation, as such. I am not so modest but what I feel that my own books, WATER—OR YOUR LIFE and TIMBER IN YOUR LIFE are books in this category. So are the yearbooks on Water and Soil.

Now, to finish this off, the Conservation Library Center asked about fifty conservationists the books that they recommended as being the most important to a basic library. We had something around 180 books recommended as being primary in the conservation field. However, there were books in these groupings that were repeated several times. They total something over 60. I am going to ask my secretary to take the cards that we worked up from these replies and to check off the fifteen top books.

Best regards and good luck with your paper. There is need for just what you have as a subject and the discussion that pertains to it.

Sincerely,
/s/
Arthur H. Carhart
Consultant
Conservation Library Center

ARTHUR CARHART'S TOP FIFTEEN

American Forest Management—Davis, K. P.
Animal Ecology—Elton, Charles
Conserving Natural Resources—Allen, Shirley W.
Fifty Years of Forestry in the USA—Winters, Robert K.
Forest and Range Policy—Dana, S. T.
Freshwater Fishery Biology—Lagler, Karl F.
Game Management—Leopold, Aldo
Man's Role in Changing the Face of the Earth—Thomas, William L., Jr.
Natural Principles of Land Use—Graham, Edward H.

Sand County Almanac—Leopold, Aldo
Soil Conservation—Bennett, Hugh
United States Forest Policy—Ise, John
Vegetation and Watershed Management—Colman, E. A.
Wildlife Conservation—Gabrielson, Ira N.
Wildlife Legacy, Our—Allen, Durward L.

AMERICAN GAME ASSOCIATION

Vice-President
Seth Gordon
1390 Seventh Avenue
Sacramento 18, California

February 5, 1963

Dear Charlie:

I hope you won't spare the horses when you discuss that highly important subject at the Conference.

Many of the schools with specialized courses have been aware of their shortcomings, and have made an effort to correct them. But in many instances they can't get out of old ruts.

I have hired a goodly number of graduates of such schools, as you know. I have tried to help them grow, or watched them fumble around . . . until they finally got out of the field or hid in a niche where they did not have to face the public.

Many of these new graduates shun public appearances, or when they have the courage to stand up before an audience, especially an unfriendly one, they use so much technical jabber (when common English words and explanations would do the job) that they quickly lose the crowd.

Ask them to discuss historic perspective and they run for cover; or get them to write a report and the stuff is so hard to read, or full of technical language, that it falls flat.

Here are a few of the non-technical books I would require:

1. Breaking New Ground—Pinchot
2. American Forestry—Six Decades of Growth—Clepper & Meyer
3. Wildlife Conservation—Gabrielson
4. Adventures in Bird Protection—T. Gilbert Pearson
5. Land, Wood & Water—Senator Robert S. Kerr
6. Crusade for Wildlife—Trefethen
7. Silent Spring—Rachel Carson

Then I would require courses in English, report writing, public speaking, etc., which so many of the graduates lack.

Sincerely,
/s/
Seth Gordon

January 4, 1963

Dr. Adolph Stebler, Leader
Okla. Cooperative Wildlife Research Unit
Oklahoma State University
Stillwater, Oklahoma

Dear Steb:

Will you please send me a listing of all the *required* courses and *required* readings, and recommended electives, for a bachelor's degree in wildlife management or conservation, and also for a master's degree in these subjects, at Oklahoma State University? I am gathering material for a paper at the next North American Wildlife Conference on whether or not our wildlife graduates are getting sufficient grounding in history—specifically, history of natural resources and public land management and conservation in the United States.

I am making the same request of all the other Coop Units.

Thanks for your help,
/s/
Charles H. Callison
Assistant to the President

DISCUSSION

MR. DAN SAULTZ [Missouri]: I have no questions or challenges, because I agree with him implicitly. I would like to comment that we have found this situation he describes at all levels in our department, and we have attempted to alleviate this or compensate for it by having certain required reading for all personnel who come into our department, whether they be foresters, fishery people, game people, or conservationists or whatever. We require all of them to do certain required reading. I might add that in Missouri we also require and test them over a book written by Mr. Callison.

MR. VESSEY: Do you want to comment on that, or say thanks?

MR. CALLISON: I will say thanks.

MR. FARLEY [Michigan Department of Conservation]: I had a type of speech cooked up on the first paper, and I boiled it down considerably so I won't be quite that long, but I think that the problem we are confronted with today is how are we going to put some of these things in operation that we are talking about today, and I believe every one in the room will agree that possibly it should start at the college level of at least getting people turned out by colleges that are proficient in more than just the technology that is the case or that they specialize in. It so happens, I think, that most technologists dream of being scientists as they go through the classroom work. Most of them don't end up as scientists, but we get them all trained basically for that purpose, and out of that, we get a few of them that might fall within the scientist field, and then the rest of them become managers, and they deal with people. Think of the energy that we put into the problem of people in our conservation department, of people problems. Douglas Wade spoke to the point regarding this subject that I am going to talk about and that is that we need research, and we need it badly. We are practitioners of a sort. We are unguided in our dealing with the public. We need a tremendous amount of research. Where is it going to come from? I think that is one of our first questions we have got to answer, because we are going to go along just as we are now unless we get some assistance. That brings up a delicate subject of where are we going to get the money in our new stage or how we are going to get the money equivalent, we'll say, for studying people problems as we can rabbit problems? Our conservation administrators are not inclined to do that sort of thing. The sportsmen's pressure is on. The rabbit problem is there, and we can get the money for it, but we've got to deal with people because people are the only reason for the rabbit being in the first place, and we have a man named Wilson, I think, from Minnesota, who one time promoted rather vigorously the use of PR funds for educational work. We know the arguments against this. I have been for it and against it both, but if we could direct some money that now goes into rabbits and deer and this and that and the other thing in the wildlife field into the management of people and the study of people so that we could treat these things effecively, I think we could get rid of the political implications that were involved in the other sort of arguments.

MR. FARLEY: I had a long one cooked up here. Anyway, the other argument is, should the wildlife man here and the wildlife society be a body of technicians, or should we treat it in the mass, as you might say, as a group of people that are working along on their own problems because they are working with wildlife problems. They are working with people, and we could insert it stronger in the constitution so that all the paper and all the time devoted to the wildlife conference wasn't devoted to discussing the animals.

STIMULATING COMMUNITY ACTION IN THE AREA OF CONSERVATION

HUGH B. MASTERS

Director, Center for Continuing Education, the University of Georgia, Athens

The subject of community action implies some continuous and systematic plan or procedure which will insure the success of the process. The idea requires some structure that is in keeping with our concept of a free society, and it must take into consideration the existing regulations, organizations, and vested interests. The structure should involve people in the planning stage in such fashions as to satisfy them emotionally and rationally every step in the total process.

It will be the thesis of this paper to suggest a new look at an old social invention that has been widely used in spite of the fact that relatively little is known about this social phenomenon. It has been both praised and condemned, ofttimes without study. It is usually formed in times of social crisis demanding some form of group action. In such cases the crisis demands the action of the machinery rather than the programming. The stimulation of community action in conservation is no different from stimulation of communities to act for other goals.

The organizational structure that is suggested for this stimulation is the structure that has come to be known as the council.

When or where the first council was developed is not known; neither is it known precisely why or how the council idea was first used. Its origin and development can, however, be traced back to the period when primitive man began the formation of tribes and the establishment of group living. Since then there seems to have been almost continuous attempts to use the idea in many different ways. Although its general use in the highly complex culture of the present day may cause its purpose to appear to differ greatly from that of tribal groups, basically it has changed little. Today that purpose is described in terms of achieving by democratic procedures a more systematic control over a given situation.

Throughout the long and varied use of the council it is significant that the device has not been subjected to careful study based upon detailed records of council activities. Even though the usage has been so extensive, today there seem to be no written records documenting in detail how councils are developed and indicating the fundamental principles that should be adhered to in their operation. Each succeeding generation has used the council idea, improvising from time to time and making whatever adaptations seemed to be needed during its use without there being a systematic plan of transferring from one generation to the next the basic principles and know-how that are developed. Thus the literature about the council is largely of the exhortative type. The lack of study of this social instrument has undoubtedly tended to retard its effective and efficient use. Generally the employment of this important social tool seems to be characterized by the trial and error method. The widespread use of the council without an adequate understanding of it would seem to warrant research toward refining and giving better direction to this significant group process.

Another important characteristic of the council idea that has persisted throughout its history is its growth out of pressing emergencies. Modern people, like their primitive forefathers, have continued to call the council into play only when there is dire necessity for its use. This is significant in that it makes the council a stopgap device with a membership so absorbed in developing a solution to the emergent problem that little or no time is given to the study and development of the council itself. This conception and use of the council tend to prevent its being developed to enhance and extend the opportunities of improving cooperative relations and to transmit the accumulated experiences in its use as highly complex social invention.

The idea seems to be generally accepted that there is no need for a council unless a recognized problem or difficulty exists for the group to work on. Many authorities go so far as to say that when the council has disposed of the problem of difficulty that brought it into existence it should cease to function. These beliefs help to prevent the council from developing to its greastest potentialities. The council should, under ideal conditions, be working to prevent crises and emergencies, rather than itself being a product of the emergency. The significance of this concept is the emphasis it gives to the development of interdependent relationships and the extensive use of educational processes as a means of reducing the many conflicts that accrue from a highly specialized and technological culture.

In recent years the council idea has become extremely popular and is regarded by some as a general panacea for all societal maladjustments and social problems. This conception of the council idea has caused it to be widely used at all levels—local, state, and national. Often it would seem that other social devices or direct administrative procedures on the part of the persons involved would have been much more effective and efficient in securing the desired results. The chief value of the council idea appears to be in the area of cooperative action that leads to cohesion of the various agencies simultaneously permitting each one to retain and strengthen its own position in the family of public and private agencies. Even a brief survey of the purposes for which councils are created reveals that they are organized primarily to render advice and achieve coordinated action among the various community organizations. These are worthy purposes; but when viewed in light of the line of communication that councils have been able to establish to the chief policy-making officers involved in the represented agencies, the practices fall far short of achieving these two purposes. Frequently councils have little or no contact with the chief policy-making officers except in a very different manner. Studies that have been made show clearly that to be effective, coordination must be developed in the beginning stages by involving the chief policy-maker of each agency represented in the council.

There are many different types of councils, organized for adult education, safety, films, agriculture, the community, and social service. In this country they exist at the local, county, state, regional, and national levels and in some instances have many inter-locking relationships. Even though their functions and purposes seem to vary widely, in general they are concerned with achieving a new and better control over a situation, a control that is democratic and respects the dignity of the individuals and agencies involved.

In general the council has been used in four major ways. First, it has been used strictly in an advisory capacity by the member agents participating in its program. This type of use is based on the assumption that group development of understanding and know-how is greater than that by any one individual, and that a combining of the results will produce a more effective solution to the problem at hand. Still another assumption underlying this particular type of use concerns the idea that an advisory body will tend to reduce the direct pressure on the administrative agency. This limitation on the use of the council greatly reduces both its efficiency and its effectiveness as a social instrument in our culture and often results in vague general advice based on spot opportunistic decisions rather than development of programs based on research and planning.

The second major use made of the council may be described as promotional. Councils of this type frequently take on assignments for developing pressures on other organized groups and often the general public, to effect solutions to the many diverse problems in community life.

The third use of the council is as an administrative body. Its major use in this way is one of direct control and operation of programs either through existing agencies or direct contact by the council itself with the various groups involved. It is inevitable that the mortality rate of this type of council would tend to be exceedingly high. Administrative duties should be delegated to individuals. Furthermore, administration as usually attempted by councils requires the efforts of full-time staff members and cannot be done effectively or efficiently through volunteer services.

The fourth major use of the council is educational. This use is considered on a broad base employing investigation, forecasting, planning, and evaluation in terms of the evolving situation. This use operates on the basis of developing extensive techniques for educating the member agencies through programs of referral and facilitation and the processes of exchange and coordination. The council conceived in terms of this type of usage would have permanency and would seek to achieve unity in its processes through educational programs.

In the United States there has been a constant development of organized groups around the general council idea. The movement, however, in general has been concerned only with aspects of the community problems and not the totalness of situations. This has caused a great deal of confusion and increased the mortality rate among councils. National groups have tended to follow the same pattern by encouraging the organization of special groups around particular problems that concern single aspects of a community's effort.

The council's efficiency and effectiveness should, therefore, be appraised by the extent and degree to which it achieves unity of purpose and commonness of effort in terms of the relationship of needs, interests, and resources that are created.

The council as it now exists seems to be the only social instrument which, by the nature of its organization, can represent all the varying interests of a community. The unique feature of the council, which has remained basic to the idea from primitive times to the present, seems to be that it deals with the total situation and causes in the interacting agencies and individuals integration of their attitudes, values, and purposes. The council thus becomes the instrument through which organized groups and individuals can become efficiently functioning units interrelated with one another and their physical environment.

In a highly complex society such as exists today the need for and uses of a device such as the council have become increasingly exigent. Councils have increased in number and variety until they are almost beyond count. The council has developed into its present position of importance and magnitude of number, because in a society such as exists today, individuals and groups are constantly working on problems which demand a regrouping of their resources in order to effect more adequate solutions for common problems. The council as a social instrument recognizes this interdependence of man and attempts to achieve through its operation more extensive and more effective patterns for cooperative relationships.

The treatment of the community by the usual agencies in terms of segments, without due consideration for the total problem confronting it, has given rise to the development of the council idea. The planning on the part of one group for some aspect of the community welfare ultimately brings that group into conflict with the unplanned segments of community life. Some coordinating group is needed to consider the conflicts of the community and the agencies in it. The delegation upward of both responsibility and authority which would be required of already existing agencies, definitely suggests some type of organization of organized groups. This at the present is the council. Can it meet the needs of a community in a fast-changing culture as it exists today? Inasmuch as the council idea is based upon the adaptation and organization of the behavior of the component agencies and individuals of a community into a group-conscious unit, it would seem to be both an appropriate and an adequate social instrument. In practice its effectiveness and efficiency would seem to depend perhaps upon such factors as the ways in which the council deals with control, delegation, accountability, participation, unity, diffusion, and integration through its leadership.

The program, organization, and administrative processes of a council normally start by unifying the group around a common problem and allocating work to small units of its membership. This procedure permits continuous and widespread participation on the part of all its members. When assignments are worked out on this basis, there is an increase of interdependence on the various agencies and individuals which strengthens the council as a unifying force in the community.

The council is a potentially powerful social instrument in a coordinated attack on common problems in terms of the total situation, through the processes of diffusion and integration leading to unity of purpose and action. The council as a social instrument could be a powerful agent in integrating the specialized interests of the many groups in our society, particularly in urban communities.

The continuous extension of specialization means that the development of organizations has been so influenced that they too represent highly specialized interests in the community life. The council as a social instrument seems to be one device for bringing these specialized interests into a position where they can be used to study and plan for the total interest of the community involved. The usefulness of the council rests upon its distinction not as just another organization but as an organization of organized groups. Society has many devices for holding before individuals patterns of behavior for their guidance. The council is evolving similar patterns to be used with organized groups in a community.

Specialization of community interests has resulted in so many kinds of organizations developing around them that community leadership is in danger of becoming exhausted. The council, just as any organization, is limited in its effectiveness to the extent and degree to which it is able to secure the needed leadership to carry on the program. Councils must have ways and means of constantly selecting and training new leaders in its processes.

Since the council is a voluntary social instrument, its activities are almost entirely carried on in spare time or time taken from normal job requirements. This tends to cause the appointing agencies and the council members to attempt to do the work of the council in the minimum of time. There is need for careful and critical study of the amount of time needed for councils to function adequately. Often meetings are held too infrequently, for too brief a time, and at inopportune times for the members. These symptoms point the direction to many of the problems that seem to confront present-day councils.

The council must be able to involve, in a meaningful and significant way, enough of the various agencies in the community to enable it to have a total picture of the situation. If this is to be accomplished, these represented groups must be involved in the program and administrative processes of the council itself, as well as being a part of its organizational structure. Many communities and state groups attempt to organize a council without even an understanding of the nature of its organization, the character of its program, or the needed administrative processes for its operation. As a result, there has been a misuse of the council idea, causing enormous impairment to council activities.

The total community interests must suffer unless the council can be made to serve the many tangential efforts of the interacting groups within the community. Communication among the various agencies in a community, and between those agencies and the community becomes a major function of the council in the development and extension of intergroup processes.

DISCUSSION

MR. MAYALL [Toronto]: I would just like to give you an example of conservation democracy in action. In southern Ontario, there are 32 conservation authorities comprising more than some of your states. They are much larger in total area, based on drainage basis. At the wish of the public, the conservation authorities established in each organized municipality authority, one for each of so many population. The government was asked to supply a complete report on flood control and reforestation, a partial report on fish and wildlife, one on recreation, and one on the historic aspects. The report goes to the authority. The authority has the power to tax. If it taxes the people, the Province of Ontario, and it is a major problem, the federal government of Canada demands a dollar for dollar, the amounts of money spent by the municipalities. It is up to the people to decide whether they want conservation or not. Thank you.

DISCUSSION LEADER VESSEY: The chairman tells me time has run out. I am going to throw just my own little bombshell into this thing. I don't think we are going to get this conservation concept into the training of our technicians until the deans and heads of departments in the scientific fields of training develop their own in-service training program. They must see to it that their instructors have the knowledge and know-how to inject and get across this teaching during the four years a student is in college to make sure that he has a broad basis and understands conservation, so that regardless of what phase he goes into, he has that. Now, my conscience is bothering me a little bit. I was at the point of being rude in cutting off Grace Murphy this morning, but being afraid that she was getting into multiple questions, in order to get it into the record, I want to quote her again. Her main point, as I gathered, was the fact that we must get out of the classrooms and get popular, get write-ups in the popular magazines giving both, I might add all, sides of the subject to be discussed in the conservation needs, and her idea was that the Reader's Digest if properly approached might devote a section which would appear in every issue on the subject. Also, industrialists, sports manufacturers and others might support a magazine, a popular type magazine to sell on the news stands that would be devoted to this subject. I would like to indicate that I think she has a good idea, and I want to make sure that that does get into the record.

THE 28TH NORTH AMERICAN WILDLIFE AND NATURAL RESOURCES CONFERENCE: AN APPRAISAL OF THE CONFERENCE PROGRAM

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At the suggestion of President Franklin D. Roosevelt, the first North American Wildlife Conference was held February 3-7, 1936, in Washington, D. C. Its general chairman was the late F. A. Silcox, then chief of the U. S. Forest Service.

In announcing the purpose of the first conference, President Roosevelt stated an objective that is as valid today as it was in 1936: "My purpose is to bring together individuals, organizations, and agencies interested in the restoration and conservation of wildlife resources. My hope is that through this conference new cooperation between public and private interests, and between Canada, Mexico, and this country, will be developed; that from it will come constructive proposals for concrete action; that through these proposals existing State and Federal governmental agencies and conservation groups can work cooperatively for the common good."

With a registered attendance in excess of 1300, this historic assembly included the conservation-minded elite of Canada, Mexico, and the United States. Then, as now, the program was not narrowly restricted to game alone, but touched broadly on related aspects of resource management. Thus it is logical that what began as a gathering of individuals primarily to consider wildlife should have evolved into what is now appropriately the annual North American Wildlife and Natural Resources Conference.

THE FIRST GENERAL SESSION

Our present conference theme, "Conservation's Common Frontiers," has a special significance because, as every ecologist knows, natural resources recognize no political boundaries. It was especially gratifying to have Dr. Albert W. Trueman of Canada back with us, as chairman of our opening general session whose topic was "Sinews of Security." That our resources are indeed foundations of economic and social strength was emphasized by two notable addresses.

Fred A. Harrison, vice president of Canadian International Paper Company, discussed how resources, and in particular forest resources, are keys to economic wealth both in the United States and Canada. "Resources become wealth," he declared, "when they are transformed through good management into values, such as products, watershed protection, fish and wildlife development, and recreation."

In explaining the multiple-use concept of resource management, Mr. Harrison described his company's liberal policy as regards recreational uses of the forest and public travel on company private roads. In conclusion, he made a plea for orderly development of all resource values based on realistic priorities, and stressed the essentiality of cooperation among industries, governments, and wildlife groups in order to arrive at stable public policies.

It has become a tradition in our annual programs to focus attention on the social relationships of people and resources. Marion S. Monk, president of the National Association of Soil and Water Conservation Districts, noted that "we know less about the beliefs, the attitudes, the reactions, and the motivations of people toward their natural resources than the technology necessary to good management of our resources. . . . The voids in our understanding of people represent the weakest links in our coming attack on waste, complacency, ignorance, and default in protecting and developing our natural resources."

Pointing out that nations are faced with the fact of limited resources and the prospect of unlimited demands upon them, Mr. Monk declared the will of our societies to deal effectively with natural resources is as great a test of our democracies as the relentless confrontation of East and West in the Cold War. In short, he called on all conservationists to seek out and employ ways of broadening our base of public understanding.

In his customary forthright analysis of current resource challenges, Dr. Gabrielson castigated the parochial attitudes and thinking that are becoming a serious deterrent to fitting natural resources objectives and programs to emerging needs. Despite the large number of well-trained technicians, he finds a pressing lack of men in research, management, and administration with broad interest and vision, who are able and willing to communicate new ideas, to provide leadership in forming public opinion and in winning needed support. Concurrently, he sees a danger in the technical and professional societies drifting into "passive specialization," and urged them "to create more opportunities for broader resources outlook in education and training programs."

In pinpointing the specific jobs ahead—the things that need to be done administratively and legislatively by the federal and state governments—Dr. Gabrielson discussed at least a dozen by name, too many to mention here. His paper, which will be published in the Proceedings, deserves close study. I commend it to your attention.

The final paper and the highlight of the opening session was the report titled "Wildlife Management in the National Parks," presented by A. Starker Leopold, chairman of the advisory board in wildlife management appointed by Secretary of the Interior Udall. Because of its far-reaching future implications, this report was one of the most significant ever presented at a North American Wildlife Conference. It disposed of a most controversial subject—public hunting of excess game populations in national parks—in a paper that was scholarly, logical, and persuasive. In summary, the advisory board declared that "control of animal populations in the national parks would appear to us to be an integral part of park management, best handled by the National Park Service itself." As regards public hunting in national recreation areas, the board, recognizing that these are by intent set up primarily for recreation, favored hunting as an appropriate recreation activity.

THE TECHNICAL SESSIONS

Regretfully, limitations of time prohibit adequate appraisal of the 42 papers presented during the six excellent technical sessions. They will be published in their entirety in the Proceedings. Through the coöperation of the discussion leaders, condensed reports on the six sessions were written; but these alone total more than 3,000 words and it is obviously impossible to include them in this summary. Accordingly, with apologies for failing to discuss individually all the splendid technical papers presented, I shall mention only six, one from each session.

In the session on wetlands and inland water resources, Albert M. Day of the Pennsylvania Fish Commission, reporting on fishways on eastern rivers, reviewed the ruinous results of dams and pollution, told of their effect on anadromous fishes, and offered practical suggestions through the use of fishways for restoring desirable species. In particular, he discussed the possibilities for restocking the shad, which historically has been unresponsive to fishways found satisfactory for many other species. If the Pennsylvania Fish Commission can re-establish the shad fishery in my native state, it would be one of the major resource accomplishments of the present century. May success attend this worthy project.

Among the seven excellent papers presented during the session on "Disease, Nutrition Controls" I mention one because of its significance to public health. Rabies has changed from a disease of dogs to an infection predominantly found in wild animals. Dog rabies has declined from some 8,000 cases in 1946 to less than 600 in 1962. But reports of rabies in wildlife have increased from less than 1,000 in

1946 to some 2,000 in 1962. The species most commonly reported as infected are foxes, skunks, and bats. Five human deaths have been attributed to rabid bats. In view of the fact that bites from rabid wild animals are increasing, let us hope that the research now being conducted by the U.S. Public Health Service's National Communicable Disease Center in Atlanta will be intensified to the end that effective means of control may be devised. We are indebted to Ernest S. Tierkel for an informative report on a most important public health topic.

In the session on field and farm resources, a paper that received considerable comment was given by Forrest V. Durand of the Tennessee Game and Fish Commission. Dealing with small watershed projects and wildlife, it discussed a serious problem relating to the preservation of wildlife habitat. This problem, he explained, results from the tendency within watershed projects to justify their creation through practices which support increases in crops and improved pasture, which are now producing in excess of consumption, to the detriment of wildlife, which is in short supply. He made a convincing argument for consideration of all resources during watershed project planning, claiming that economic justification for such projects does not exist if some resource values must be destroyed. The watershed program, he concludes, is our last hope to achieve true conservation of natural resources and must have the support of all.

Among the noteworthy papers given at the session on coastal and marine resources, I invite your study of Richard H. Pough's "Safeguarding High Yield Coastal Areas." His effective highlighting of the problems involved in the preservation of such areas in the face of industrial developments, particularly in the oil refinery and petrochemical fields, contained a calm and reasoned challenge for both sides to acquire accurate information on suitability of sites for safeguarding and for industrial zoning, without resort to bureaucratic legislation.

Among the corps of practicing conservationists, one of the most observing is Charles H. Callison of the National Audubon Society, who explored the need for historic perspective in conservation in the session on "Conservation Information and Education." His paper grew out of his belief that the biologists being graduated by the fish and wildlife management schools are insufficiently grounded in the history of the land and resources they work with, and of the agencies or institutions they work for. When such a gap in his education exists the biologist is ill-fitted to understand and deal with problems he must inevitably confront in public relations, and, if he hopes to rise to a policy making position, in public administration. It also leaves him at a disadvantage in providing guidance to citizen groups concerned with the renewable resources. Such groups, if they are to do good, must operate in the forums of public opinion and politics. Their leaders also need historical perspective. Callison has undertaken to examine the curriculums in the wildlife or conservation departments of several universities, and will try to identify the shortcomings in historical teaching. He will then offer recommendations for filling the gaps.

At that first historic North American Wildlife Conference held in 1936 I had the honor to present a paper on deer damage in the forests of Pennsylvania. Our techniques of determining damage in those days were pretty crude, and my recommendations, based on those techniques, are now mercifully forgotten. But my personal interest in deer studies continues, and I found fascinating the reports of a ten-year study of an enclosed deer herd, given in the session on forest and range resources, by David A. Arnold and Louis J. Verme of the Michigan Department of Conservation. The inventory methods used by these capable scientists were unheard of three decades ago. For example, had I proposed in those days to take X rays of pregnant does, I would have been invited to seek a job elsewhere, preferably in another state. But such technical devices as telemetry and X rays are now commonplace. And such valuable research as that being done by Arnold and Verme, and by hundreds of other competent biologists, deserves our respectful recognition and support. For, let us never forget, research, together with sound scientific education, provides the base on which our efforts as resource managers will succeed or fail.

THE SECOND GENERAL SESSION

"Conservation's World-Wide Challenge" was the theme of our second general session. We are honored to have the eminent educator, Dean Rudolph K. Froker of the University of Wisconsin, to serve as chairman; and as vice chairman, G. W. I. Creighton, of Nova Scotia, one of Canada's outstanding provincial lands and forests administrators.

In the opening address Secretary of Agriculture Freeman called for new ideas to satisfy the ''unmet needs of the nation'' for outdoor recreation. Noting that by the year 2000 the demand for recreation should triple, he described the impact already being felt by his Department as a result of urban created demand.

Recreational visits to the national forests alone have increased 340 per cent in the past decade, he said. From 113 million visits in 1962, he predicted over 300 million visits by 1980. Notwithstanding the greatly increased recreational facilities provided by the Forest Service, the Secretary acknowledged that they will not be enough.

''But with the expansion of recreational opportunities on privately owned land—the farms, ranches and woodlands that make up 75 per cent of our land area—the demand can be met,'' he believes. This, he said, "outlines the need which propels us into a new frontier of conservation"; and proposed to promote the application of multiple use to private lands through the Rural Areas Development program enacted in 1962.

In keeping with the theme of the conference was the paper ''Technical Assistance: Needs and Opportunities'' by Herbert J. Waters of the State Department's Agency for International Development. It was encouraging to hear of the extent to which technical assistance operations in the less well-developed nations are, with the participation of local populations, helping make arid lands productive through soil and water conservation projects, through reforestation, and through improved agriculture. On some other occasion, we should like to hear more from AID about specific projects on which American foresters, soil conservationists, range managers, and wildlife and fisheries managers are working. It is our understanding that there are dozens of these resource technicians scattered around the world. We are proud of their contributions to the improvement of world conditions.

Especially encouraging was the account of international cooperation in conservation by Harold A. Vogel, North American representative of the Food and Agriculture Organization of the United Nations. As one who has served as a forestry advisor to the United States delegation at FAO conferences in Rome, I can testify to FAO's useful program in natural resources and to the qualifications of its technical personnel. While sitting at the conference table with technicians in fisheries, forestry, range, and wildlife from the many diverse nations that are members of FAO, I have been impressed by the confidence shown by newly independent people in their ability to develop and manage their natural resources. With the help that we in the more fortunate nations can give, particularly in education and training, these people are eager to apply sound management practices to their resource needs.

FAO has been signally useful in promoting the concept of international consultation as a means of tackling the solution of the imbalances between the ''have'' and the ''have-not'' nations. Of concrete service have been the regional commissions in such fields as fisheries and forestry. Special technical study groups—as for example, in forest tree genetics—have promoted cooperation in resource development. How far reaching are FAO's activities was illustrated by Mr. Vogel's statement that FAO sponsors more than 80 technical and inter-governmental meetings and workshops concerned with specific aspects of resource development.

It was appropriate also that we should have heard from the recently appointed dean of The University of Michigan School of Natural Resources. Dr. S. H. Spurr defined the three general areas where education is deeply involved in world-wide resource development. The first involves the development of highly skilled scientists, educators, and administrators to provide the basic knowledge on which natural resource development must ultimately rest. This area is the prime responsibility of our great universities with their complex of graduate offerings and opportunities for individual research and scholarly activities.

The second level of education in natural resource development, he said, involves the training of competent technicians and professional conservationists. It is the professional wildlife manager, the professional forester, and their counterparts in other conservation fields who must put into practice the measures that will assure wise use of our resources. Their education is primarily at the undergraduate level, and is carried out at a much larger number of colleges and universities.

Third, according to Dean Spurr, education must create an awareness of conservation problems among the citizenry of a country before the people themselves will support programs for the sound management of natural resources. This awareness must be inculcated in the minds of students in our elementary schools, secondary schools, and colleges, as well as in the general populace through radio, television, and general extension activities.

THE SUMMING UP

As we look back over the past 28 conferences we may perceive an increasing responsiveness and responsibility by the managers of natural resources to society. Especially apparent in the general sessions has been a sense of recognition by the speakers that conservation for its own sake is not enough; that man, who is himself a natural resource, must by self-evaluation lead humanity in purposeful thinking and action toward world resource sufficiency.

According to the official registration records of the 28 conferences, attendance has exceeded 26,000. Such interest justifies holding the conferences, and as a faithful attendee I hope that the Wildlife Management Institute will long continue to sponsor them. Indeed, this

28th conference, like its predecessors, has been a good solid meeting. Also, like its predecessors, the significant facts and observations reported have been eminently worth emphasizing for the attention of the conservation-minded community.

James A. Craig, editor of *American Forests* magazine, who has attended innumerable conferences and who has appraised them from a reporter's critical viewpoint, was asked for his capsule comment on this one. He gives it as follows: "Challenging statements from a variety of disciplines have featured the 28th North American Wildlife and Natural Resources Conference. But none of these, including the inspiring report of the Leopold committee, is the most notable feature of the conference. The most notable feature has been the keenness, the awareness displayed by a new breed of skilled technicians—wildlife managers, water and soil specialists, foresters and others—who have exchanged ideas and criticisms with a vigor and objectivity not encountered at many previous conferences. This is the conservation wave of the future and one can't help but believe that these newcomers will be more than equal to the challenges laid down by a Leopold committee and all the other challenges encountered in this expanding movement."

Yes, our general and technical sessions have been replete with sound reports on progress in resource conservation, on scientific developments, on observations of biological phenomena. But notwithstanding our awareness of the role of resources in human welfare, we must do more than simply be aware. In short, have we faced up to our greater responsibility as molders of human action? How can America at large be more adequately alerted and informed?

For our problem, in a nutshell, is how to communicate with the general public. Thus, if asked to identify our most promising, as well as our most challenging, opportunity in natural resources I should say, "communication." Scientific research and education are, of course, fundamental to everything. Let us never underestimate the importance of new facts and ideas in resource development. But today many thinking people have little time for natural resources. They are more concerned about those military aspects of international competition that could blow us into oblivion overnight. Granted that nuclear war is an ever-present hazard that man would be fooilsh to ignore. But is it any less inevitable than the massive erosion of the physical earth and the biological wastage that accompanies it?

In my considered judgment, the greatest threat, not only to our nation, but to the entire world is mankind's ingrained and indifferent acceptance of the inevitability of loss, misuse, and spoilage of our resources. We face our greatest danger when human society becomes habituated to enlarging scales of resource losses.

Do I exaggerate? Then what about the continued pollution and siltation of our waters? What about the deterioration of our range lands? What about the hundred thousand fires that annually ravage millions of acres of our woodlands? And, for that matter, what about the dangers of human overpopulation? For human survival depends not alone on preventing the annihilation of people by nuclear war. Survival depends equally on preventing destruction of air, land, and water resources, competition for which by swelling human masses may precipitate such violence.

In closing, I venture to pose a question which, if rhetorical, is nevertheless serious and pertinent. It is this: "Are we failing as a people to take prudent action to offset the harmful consequences of world-wide exploitation and destruction of renewable natural resources?"

My answer, based on four decades of searching for the verities, is that we are not failing. We have two reasons to be optimistic as to the future. They are, first, our scientific and technical capability; and, secondly, our proven ability to cooperate among ourselves and to collaborate with people of good will everywhere in the attainment of socially desirable goals.

CLOSE OF THE 28TH CONFERENCE: FORMAL ACKNOWLEDGMENT OF APPRECIATION FOR COOPERATION

C. R. GUTERMUTH

Vice-President, Wildlife Management Institute, Washington, D. C.

In behalf of the Wildlife Management Institute, which sponsors these annual conferences, I wish to thank my good friend Henry Clepper for one of the most outstanding critiques and summaries of the entire program that we have been privileged to hear. Each year we have picked a distinguished leader in the field of natural resources conservation and management to undertake this arduous task, and the list of past summarizers is becoming a virtual Who's Who of conservation. Few men have been associated more closely with the planning of the North American Wildlife and Natural Resources Conference than Henry, who has attended just about every meeting of the program committee for the past 20 years. His assistance as a working member of the sub-committee has been invaluable. We have tried for a long time to get Mr. Clepper to serve as summarizer, knowing that he would do a superlative job, and the highest praise that I can give to his efforts is to say that his critique has come up fully to our expectations. Henry, thanks very much.

Sincere thanks also are due to The Wildlife Society, and especially to Stewart M. Brandborg, who represented the Society in formulating the agenda of the technical sessions. The members of the General Program Committee, which includes the heads of most of the national organizations and federal agencies, already know how much we appreciate their help. Mr. Brandborg is singled out for special thanks now because the well-balanced programs of the technical sessions reflect his efficiency and painstaking effort.

We are grateful to the press for its coverage of the conference. The Detroit papers have given us considerable space, and I understand that the wire services have done as well or better. The New York *Times* did all right by us in its West Coast edition, which helped to offset the let down in the Northeast. Dan Poole worked hard to provide the working press with abstracts and papers, and prepared numerous releases on the highlights of the conference.

We are indebted to the Statler Hilton Hotel for its assistance in meeting the needs for space and other facilities for the conference, and to the Detroit Convention and Visitors Bureau for its efficient and courteous handling of all registration details. The musical and variety show by Jack Morton Productions was up to standard—it is becoming more difficult to give you good shows year after year.

Now, please join me in expressing appreciation to those two patient persons who do so much to make the conferences successful, and whom I am asking to stand: Mrs. Gabrielson, and my wife, Bess—they deserve a real ovation.

While neither the registration nor the attendance record is a fair measure of the success of these conferences, we had more than 1,100 people registered at the last count, and a capacity crowd of over 500 at the annual banquet last evening. The things that count most are the audience participation in the discussion periods and the proportionate attendance in the various sessions. By all standards, this 28th Conference ranks among the best.

Good luck and best wishes. We are planning to go to Las Vegas next year, and hope to see you at that fabulous place on March 9, 10, and 11. Take it easy going home—happy landings.

REGISTERED ATTENDANCE AT THE CONFERENCE

ALABAMA

Ralph H. Allen, Jr., George A. Averitt, Mrs. George A. Averitt, Maurice F. Baker, I. B. Byrd, F. H. Farrar, Earl F. Kennamer, Raymond D. Moody.

ALASKA

Ed Bellinger, Bud Boddy, James W. Brooks, Frederick C. Dean, Albert W. Erickson, Richard M. Hurd, David R. Klein, Sig Olson, Gordon W. Watson.

ARIZONA

Fred Faver, Lee Hover, Roger Hungerford, Clay McCulloch, Robert J. Smith, Wendell G. Swank.

ARKANSAS

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