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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 29th North American Wildlife and Natural Resources Conference.

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PART I
GENERAL SESSIONS

GENERAL SESSION

Monday Morning—March 9

Chairman: IRVING K. FOX
Vice-President, Resources for the Future, Washington, D. C.

Vice-Chairman: J. WHITNEY FLOYD
Dean, College of Forest, Range and Wildlife Management, Utah State University, Logan, Utah

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SHARING THE RESPONSIBILITY

FORMAL OPENING

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

It is a pleasure and a privilege to open the 29th North American Wildlife and Natural Resources Conference in this fascinating and unique city of Las Vegas. This is the first time that the Conference has been brought to this part of the country and only the second time that it has convened in a city west of the Great Divide. This is not due to any lack of interest in the affairs of the western states on the part of the Wildlife Management Institute, which sponsors these annual international conferences. We are as deeply concerned with the natural resource problems of the West as with all of the other regions of the United States, Canada, and Mexico.

In selecting a site for each Conference, the Institute has been forced to consider the geographic distribution of the population and the somewhat special hotel facilities that are required to stage a series of meetings of this kind. Perhaps nothing could be more symbolic of the recent population shifts in America than the mushroom-like development of this ultramodern city from a small historic mining town in the middle of a desert. Ten years ago it was almost impossible to find a hotel between the Mississippi and the West Coast that could handle this conference. Today there are dozens. With these two obstacles to western locations overcome, we may be able to have more conferences in the West. We came close to breaking the all-time registered attendance at the 15th Conference in San Francisco in 1950, and the large crowd here this morning makes me think that we did not make a mistake in coming here this year. We can judge that better by the way you remain in the meetings.

It has been my pleasure to attend about thirty of these international meetings; I have staged 19, and there are a lot of familiar faces in the audience. Many of you are attending your first conference, however, and for your benefit it is necessary to explain the purpose and function of these meetings before turning the meeting over to the chairman of this morning's session.

All of the programs of these yearly conferences are developed by a rather large committee representing many conservation agencies and organizations, public and private, from the United States, Canada, and Mexico. The technical sessions are formulated under the direction of The Wildlife Society, and the Institute provides all of the necessary facilities and conducts the meetings.

As a true conference, and not a membership convention, the North American Wildlife and Natural Resources Conference is a forum and affords an opportunity for those attending to confer, to learn, observe, and discuss subjects of mutual interest. The Conference does not take action or pass resolutions. Seated around you are representatives of various private organizations with divergent views, and officials of federal, state, provincial, and local agencies whose responsibilities for the respective resources may vary considerably. Most of them are not in a position to commit their organizations or agencies to any particular position that might be acted upon in a meeting of this kind. Because of this, no motions or resolutions can be entertained. The chairmen of the various sessions have been requested to rule out of order any resolutions that might be presented from the floor.

The Institute hopes that the papers that will be presented and the ideas that will be discussed in the meetings, both on the podium and from the floor, will be the basis for much action in the future. But whatever action results, it must be taken subsequently by the respective agencies, organizations, and societies here represented. The sole purpose of the Conference is to provide a clearing house for new ideas and to suggest new approaches toward meeting the serious conservation problems of the Western Hemisphere.

You will note in your program that scheduled discussion periods are provided after the formal presentation of each paper. We urge all of you to take full advantage of this time to comment or question.

All that we request is that the remarks or questions be germaine to the subject of the speaker. All discussion is being recorded and will be printed in the published Transactions.

The Institute feels that the program committee has developed an excellent program, covering a broad scope of subjects that will be discussed by a distinguished panel of experts. We sincerely hope that this Conference will give all of you a fresh outlook and suggest new approaches to the conservation problems that all of us must face.

Now then, rather than break into the meeting later, permit me to make a few brief announcements at this time.

It is important that all of you purchase your banquet tickets as soon as possible. This year, we have something really special in the way of entertainment. The hotel has turned over the Congo Room to us tomorrow evening, and we will have the "Sahara Spectacular Floor Show" for our banquet entertainment. Your banquet ticket this year represents the bargain of a lifetime, but if you hope to get choice seats you must purchase your tickets immediately.

The dinner of The Wildlife Society is tonight, and those of you who plan to attend should purchase tickets at the Society's desk before noon today. This is important; the hotel must be given a guarantee.

Finally, the ladies must pick up their guest tickets for the Ladies' Luncheon at the conference registration desk before 10:00 o'clock this morning. This year, the Institute has chartered a bus to take the visiting ladies to the Mint and Lucky Casino for a picture of the gambling business in Las Vegas. The one bus will leave the Sahara promptly at 1:45 p.m. this afternoon after the ladies' luncheon. All of the women who wish to go to the luncheon must pick up their guest tickets without delay.

Thank you for your courtesy. Now then, it is a privilege and an honor to turn the meeting over to the chairman of this opening General Session, the distinguished vice-president of Resources for the Future in Washington, D. C., my good friend and a talented and capable conservationist, Dr. Irving K. Fox.

REMARKS OF THE CHAIRMAN

IRVING K. FOX

The theme of this conference is "Resources for the Good Life." This reminds us as to how much the nature of the natural resources task in North America has changed in the last 15 years.

Most of you will recall our concern in the immediate post-war period as to the danger of running out of the basic resources—land, water, timber, minerals, energy—required by a growing population and an expanding economy.

The reports of the two Hoover Commissions, the Paley Commission report, and the Truman Water Policy Commission report reflected this concern. This was a major stimulus for the establishment of my own organization, Resources for the Future.

Today we face the danger of resource shortage with greater confidence. Scientific advances, as well as new discoveries, hold the promise for the foreseeable future—a generation or more at least—that we can supply the resource commodities required by an expanding economy at little, if any, increase in cost. Implicit in this outlet is the continuing need to husband our reserve in the manner the great conservationists have taught us and a recognition that human population increase at present rates cannot be supported indefinitely.

At the same time, it is evident that for the next generation at least we can supply the food, the fiber, the minerals, the energy and the water for rising living standards.

In the meantime, we recognize that we have an immediate and critical problem. Stewart Udall has called it the "Quiet Crisis." It has become abundantly clear that the quality of human life can deteriorate sadly amidst quantitative abundance. We may have 100 million automobiles, but we may live in a smog-ridden atmosphere. Our food supply may be abundant, but it may contain insidious poisons to the human body. We may have marvelous systems of transportation, but the landscape may be cluttered with unsightly structures and the wilderness invaded. There may be plenty of water in each tap, but beautiful valleys may be inundated by storage reservoirs. In short, we know that in our effort to have enough that some of the most important values we seek may be destroyed.

This is the challenge to the modern conservationist in North America—not resources to survive, but resources to make survival worthwhile.

It is fitting indeed that the theme of this conference is, "Resources for the Good Life," and that our first speaker should deal with, "Human Needs and Resource Values."

I wish to introduce to you Mr. James E. Gibson, who is with the Peace Corps at the present time and is Assistant Director of the Division of Recruiting.

HUMAN NEEDS AND RESOURCE VALUES

JIM GIBSON
Assistant Director, Office of Public Affairs, Peace Corps, Washington, D. C.

Last week Eric Sevareid ended his syndicated column with this paragraph:

"In the very recent time of Pope John and John F. Kennedy, a new vision was beginning to take form and substance. It must not be allowed to fade away into the musty mists of good intentions."

I am here to testify to the fact that this new vision that Mr. Sevareid referred to may be likened unto a modern-day pillar of a cloud that leads us by day, and a pillar of fire that leads us by night. For the Peace Corps is a living memorial to the ideas and ideals of John F. Kennedy. It was his own creation. And, like him, it has had, in its own way, a tremendous impact among the people of the world.

Our late President was a symbol of peace and hope to the little people of the small towns and villages throughout the free world. His death was the occasion of the "first world-wide mourning in the history of man."

In Nepal, villagers walked for more than five days to the place where Peace Corps Volunteers were working just to bring them the news. In Iran, one Volunteer was approached on November 22 by a host country worker, who with tears in his eyes, announced, "Our President is dead."

Few persons in our own country had any real conception of the place this man had found in the hearts and hopes of this world's peoples. Here was a man with the world's largest aresnal of thermonuclear weapons under his control. But, his real power among men was the power of his ideas and ideals—not his weapons.

With this new vision we may find a clearer understanding of our strength as a nation and how we can use that strength to help create the kind of world we would like to have.

Back in January, Sargent Shriver visited Volunteers in several countries of the Near East and Asia. In Thailand, he received an honorary degree from Chulalongkorn University—only the second awarded to an American. It was in honor of the work the Peace Corps did in that country. At the ceremony the Foreign Minister of Thailand said:

"Many of us who did not know about the United States thought of this great nation as a wealthy nation, a powerful nation, endowed with great material strength and many powerful weapons. But now, many of us know that in the United States, ideas and ideals are also powerful. This is the secret of your greatness, of your might, which is not imposing or crushing people, but is filled with the hope of future good will and understanding. It is indeed striking that this important idea, the most powerful idea in recent times should come from this mightiest nation on earth—the United States."

In the Dominican Republic a group of people were writing "Yankee, Go Home" on a wall, while a Peace Corps volunteer watched. When they had finished he said, "I guess that means I'll have to go home." They turned and said, "No, we mean Yankees, not the Peace Corps."

Recently in Africa, a child, seeing a volunteer enter the village, turned to his mother and said, "Look, there's a white man." "No," she answered, "He's not a white man. He's a Peace Corps Volunteer."

Perhaps the best example was expressed by a local official in Sarawak, when he said of the Volunteers who were helping him cut a road through the jungle, "They're not your people anymore, they're mine."

No, power alone is not the secret. Victor Hugo once said, "No army in the world can withstand the strength of an idea whose time has come." The ideas and ideals of a small group of dedicated and determined men made possible our own revolution. This is also the secret of success of Christianity—and even Communism, for that matter. History proves that men who combine practical action with commitment to ideals have a far more profound and enduring impact than those who simply seek power and wealth.

Men like John Wesley Powell, Gifford Pinchot, John Muir, and others like them, were practical idealists. So were the Roosevelts. Without them, conservation of our natural resources, as we know it today, might be a dirty word.

On the human side, the list is long in medicine, law, education, and welfare, while the ideas and ideals of Abraham Lincoln and John F. Kennedy were amazingly parallel to a tragic degree.

As a people, Americans have not lost their heritage of practical idealism, in spite of our interests in the material comforts of life. Freedom, racial justice, human welfare and individual dignity are not just casual rhetoric. They are deep commitments for all of us as individuals as well as for the Federal Government.

When the Peace Corps was established on March 1, three years ago, there was much skepticism abroad that American citizens would be willing to give up their luxuries and comforts to live and work in the developing countries. The whole idea seemed silly to a lot of people here at home. You may remember "The Kiddie Korps," the "Second Children's Crusade," and "Do-gooders in button-down collars and Bermuda shorts."

In spite of the hoots and cat-calls, 20,000 persons applied the first year, 25,000 applied in 1962. The number was 38,000 in 1963. At the rate of over 5,000 a month for January and February, it looks like 50-60,000 in 1964. Have we lost our idealism?

Certainly the Peace Corps is committed to an ideal. Volunteers believe that with their own hands and skill they can cross boundaries of culture and traditions to meet others on the common ground of service to human welfare. Seven thousand five hundred volunteers now serving in 45 countries have all given up opportunities to live comfortably in America, to go to distant areas of the world, to work without pay, under difficult and sometimes hazardous conditions.

They have done this because they have found more meaning in service than in the pursuit of pleasure or the easy life. Nothing is more astonishing to people around the world than to see young Americans choosing to leave the United States to share their lives with less fortunate citizens of other countries. And they do this not because they have to, but because they want to.

As a people, Americans care. There are exceptions, of course, like the vandals, the criminals, the hate-mongers and the selfish. The average citizen may not go out of his way to seek out the needy, but publicize the plight of the policeman's widow or the sick child and the response is usually generous.

As an organization, the Peace Corps cares. Volunteers are overseas because they want to help people learn, or take care of their health, or increase their agricultural production, or raise their incomes. They show they care by being there, by demonstrating every day, with their work, that they are trying to help. In a remote village of only 500 people in Afghanistan, a volunteer lives as a teacher. Throughout the entire valley, spread over many miles with 20,000 people, he is known as "the American who has come to teach us."

About two years ago after I had spoken to a church group, during the question and answer period, an elderly lady said to me, "But you'll never go where the missionaries haven't gone." I said I didn't know where that would be because I thought missionaries had gone everywhere. "You'll never get to Afghanistan," she said.

It just happened that day before I left Washington on that trip, 9 Volunteers—the smallest Peace Corps contingent ever sent abroad—had left for Afghanistan. She couldn't believe it. Sure, the Afghans were skeptical. They had never really liked foreigners. But they liked the Peace Corps idea—if it would work in their country. For a long time the Volunteers could not go outside Kabul, the capital city. There are now 65 Peace Corps Volunteers in Afghanistan and they are no longer restricted to Kabul. They work all over the country.

During Sargent Shriver's visit to Afghanistan in January he was asked to send 220 more Volunteers to that country where even the missionaries had never gone before.

Over 700 Volunteers have now completed their two years of service and have returned to the United States. They are moving into responsible positions in industry, government, education and community service. Many are back in college continuing their studies under special scholarships, fellowships and assistantships being offered exclusively to returning Volunteers. Some have remained overseas, taking jobs with foreign governments, industry or attending school.

They have lived with the peoples of other cultures, they have shared their lives, their hardships and their blessings. They have learned a strange language and have broadened their own horizons. They return home seeing their own country and the rest of the world in a new light—with a new vision.

It would be ideal if every American could have this experience. For as Emery Reeves said in *The Anatomy of Peace*:

"Nothing can distort the true picture of conditions and events in this world more than to regard one's own country as the center of the universe, and to view all things solely in their relationship to this fixed point. It is inevitable that such a method of observation should create an entirely false perspective. Yet this is the only method admitted and used by the seventy or eighty national governments of our world, by our legislators and diplomats, by our press and radio . . .

"Within such a contorted system of assumed fixed points, it is easy to demonstrate that the view taken from each point corresponds to reality. If we admit and apply this method, the viewpoint of every single nation appears indisputably correct and wholly justified. But we arrive at a hopelessly confused and grotesque over-all picture of the world."

In spite of hardship, frustration, and a two-year absence from friends and loved ones at home, they are proud of their service and confident of their future. They are encouraging others to follow in their footsteps. They warn the strictly idealistic applicants, and stress the need for "practical idealism."

As Tom Carter, Peace Corps Volunteer in Peru, puts it:

"I live in a picturesque bamboo mat house I built myself. I buy water from a picturesque boy with a burro loaded down with water cans. I read and write under a kerosene lantern, sleep on a cot, and cook on a camp stove. Tourists and reporters find this fascinating and 'out-doorish' and envy my experience. They think I'm kidding when I suggest that we trade. How could I pass up living so picturesque! Their mat house would not be so picturesque during a 3:00 a.m. rainstorm, when water gets in their expensive cameras, or during the frequent dust storms that will stop up radios so they can't hear the Voice of America broadcasts. Their water boy won't be picturesque either when they see where he gets his water, or their cot so 'out-doorish' when they lie on it doubled up with dysentery.

"This is cultural shock and you don't find it mentioned on the recruiting posters. But do I indict the Peace Corps and warn all to shy clear? No, on the contrary, I invite, more, I challenge you to apply. If you are a tough minded realist, remembering it's for two long years of hard work—not a junior year abroad—you'll have a rewarding maturing experience second to none. If you think it will be thrilling or picturesque, or a good story for your friends back home, forget it. We don't want you down here, and you wouldn't like it anyway.

"I have had a lot of failures, a few tangible successes, and a great deal of frustration. (I was a dreamer once, too, and my fall was hard.) Now all things considered, I think I'm doing something worthwhile. I don't think I'll sign up for another stretch, but you can't drag me away from this one."

Tom Carter, who contributed the above literary gem, is working in a community action project in one of the slum areas of Chimbote, Peru. Not far away in Colombia, the first group of Volunteers have completed their two years in a rural community action project. The "few tangible successes" of this group were summed up in the Peace Corps Congressional Presentation in January of this year as follows:

"The Colombia Volunteers could claim to have had a part in the completion of 44 rural schools, with another 55 schools under construction. They helped complete some 200 miles of rural roads. Twenty-seven aqueducts were built and 29 others started.

"Four health centers were completed and 13 others started. In 33 different areas, latrine programs were instituted and more than 1000 latrines installed. The Volunteers helped to establish 26 cooperatives. They built farm ponds and stocked them with fish. They helped built innumerable sports fields.

"But the goal of the Volunteers went far beyond physical improvements. They were sent to Colombia to help the rural people there by stimulating them to undertake self-help projects. They were there to help the campesinos learn how to help themselves through community action and cooperation."

Sargent Shriver, in a talk before the Peace Corps Staff after his return from his trip to the Near East and South Asia in late January, said, "And even though it has been only a few months since President Kennedy's death, I found around the world that there is already a growing sense of relief and gratitude that the basic beliefs and attitudes as exemplified by John F. Kennedy are still vigorously guiding the United States and that they will continue to shape its policies. For President Kennedy did not ask people to believe in him. He asked that people believe in themselves."

In a remote area of Nepal some Peace Corps Volunteers were introduced to the local citizens as "Westerners." After they had worked there for a few months a delegation cautiously approached them and said: "You can't be Westerners. What are you?" A Volunteer answered, "We are Peace Corps Volunteers." "Oh," the Nepalese replied, "and where is Peace Corps?"

Peace Corps is right here—in Las Vegas, in Paducah, and in your own home towns. It is the "real America." It exists somewhere underneath the tinsel, the gambling clubs, the swimming pools and neon signs, the racial hatred and the poverty. It is the America we are often embarrassed to talk about unless we hide it in the lyrics of songs, but to which in times of need we have ultimately managed to be true. If we have the courage to commit ourselves to this America, to work for it, to believe in it, then the new vision will indeed take on form and substance.

PRIVATE RESPONSIBILITY FOR RESOURCES

BERNARD L. ORELL

Vice-President, Weyerhaeuser Company, Tacoma, Washington

The invitation to address the North American Wildlife and Natural Resources Conference presents a rare, but welcome opportunity. As the only representative of a resource-oriented industry on your program, I feel doubly concerned about the challenge of meeting my assignment, discussing private responsibilities for resources.

The opportunity to appear here is welcomed because this group most certainly includes many of the thought leaders concerned with recreational resource use. This is a rare opportunity because I believe we on the industry side of resource management do not often enough have the chance to share our views with people like yourselves. This is unfortunate because our ultimate goals are closely aligned, yet we frequently seem to be traveling paths that are far apart. I am sure most of you would agree that the separate path approach is not the best and most logical route toward meeting *mutually* desired objectives. The fact is that we are discussing mutually compatible desires. Meeting with you here is the kind of opportunity that helps develop closer working relationships.

The theme of this conference is "Resources for the Good Life." Applying that theme to the use and management of resources I would interpret it to mean meeting our resource needs in the most efficient manner, recognizing all of the various demands, desires and requirements of our society. To do this we face the delicate and challenging task of balancing the various demands in the most equitable fashion possible.

Every group concerned with such a mutually desirable resource use goal has its own responsibilities. We in industry—the private landowners—have a responsibility to our shareholders, employees and the public. The federal, state and local governmental agencies are entrusted with a responsibility for the best administration of public lands. The individuals and groups concerned with recreational uses have an equally important concern in working to improve opporutnities for that facet of land-use. No single group has all the answers.

My assignment is to discuss Private Responsibility for Resources. Our knowledge of resource management has grown significantly over the years. We have reached a point—I believe—where this increased body of knowledge has provided a clearly defined outline of responsibility for the private owner-manager of forest lands.

There may be differences of opinion regarding these responsibilities but controversies related to land uses should not be discouraged. Healthy disagreement frequently clears the air and opens the road to sounder conclusions. Controversy, however, should not be permitted to block the avenues to mutual understanding and cooperation that are so vital to equitable solutions. Emotionally based charges, labeling industry groups with titles like "land grab gang," "special interest," and "exploiters of our natural resources," are as patently unfair as to accuse all recreationists of being "irresponsible," "gun happy," "fire bugs," or "litter bugs." These blanket indictments draw public attention but increase the difficulty of reaching desirable and compatible decisions.

In today's complex world, perhaps to the surprise of many of you, I would like to suggest that the structure of Private Responsibility for Resources includes three basic categories. These include ***Production***, *Profit* and *Cooperation*.

PRODUCTION

Land and timber are the lifeblood of the forest industry. These resources must work for the landowner if he is to meet the responsibility of serving society's needs. Production is a realistic term when used in connection with resources. Yet to some of you it may sound completely self serving. Let me suggest that the word conservation might apply equally well if we consider conservation as the balance between preservation or non-use of resources and exploitation or overuse of resources. This is no attempt to sugar coat the fact that our production responsibility is the management of resources to insure a perpetual flow of raw materials. The production must be in volumes sufficient to maintain manufacturing facilities capable of converting it into the wood and fiber products necessary to satisfy this nation's needs.

Our production—or conservation—responsibility extends to the secondary resources of privately-owned forestlands. Water, minerals, agriculture, wildlife, fish and recreational opportunities are important products of the land. Evidence that private owners recognize this responsibility is substantiated by the multitude of landowners who now practice the kind of forest management that enhances the development and continuing availability of water supplies, wildlife, fish and recreational opportunity. Millions of acres of private tree-growing land produce resources for the hunter, fisherman, camper or hiker.

Most of you are familiar with the term multiple-use. It has been subject to considerable misinterpretation, but the timber industry believes multiple-use is the key to our production responsibility. Simply stated multiple-use is the accommodation of a maximum of other compatible uses with the highest single use of the land. On private commercial forest land the highest primary use is the production of successive timber crops. The maximum use of every forestland acre is the objective of every forester.

It is obvious that all multiple uses cannot be applied to every acre. Certain areas must be set aside for limited use. Watershed protection, mining, timber harvest and grazing may be the dominant uses for selected land areas with recreational opportunities available in varying degrees of intensity. It is from this principle that much controversy stems. Watershed protection closures, game management, dams for power and flood control, fire closures and a number of other conflicts recur. Every controversy reaffirms the need for applying multiple use principles.

The highest beneficial use of private tree farms is without question the growing of trees. If these lands were not capable of profitably producing tree crops they would soon revert to some other use. For the frequently half-informed man on the street multiple-use means only the right to hunt, fish, camp and sightsee on forestlands.

The forest industry views its production responsibility as the practice of good forestry management, including soil maintenance, wildlife production, and the recognition of recreational values compatible with forest production. As I have indicated to you, all these values come from management—for the production of recognized benefits. This is the first test of private responsibility.

PROFIT

Once again, in the context of natural resources, water, wildlife and recreation, we are confronted with what many interpret as a word which means, "selfish interest." Unfortunately, profit and the great outdoors do not seem to mix well in the mind of the general public. In recent years there seems to have developed the vaguely suspicious notion that profits are the child of exploitation. The profit system, foundation of our private enterprise economy, appears rather hazily surrounded with an aura of unsavoriness. I believe this feeling becomes even stronger when directed toward the private owner of natural resources. Perhaps this attitude toward forestland owners is fostered by the idea that there is something wrong in making a profit from green trees harvested from rolling hills.

May I submit to you now my belief that profit is a basic responsibility of the private landowner. Further, profit is the only tool by which we can progress steadily toward meeting the resource demands, desires and requirements of our people. Profit is the enabling legislation that permits private investors the luxury of long-range, well-founded resource management programs. Profit is the parent of multiple-use. If we fail to make a profit, we fail our responsibility.

There is a definite feeling—which we frequently hear expressed—that profits and conservation do not go hand in hand. In reality, the reverse is true. Real conservation means use and re-use of our resources, not non-use or over-use. Thus, the forestland owner invests in the purchase and management of lands for profit. If he makes a reasonable margin on his invested capital, he is able to provide the wherewithal to stimulate conservation through intensive management of tree-growing lands to produce successive crops of timber and compatible wildlife, water and recreational opportunity. Profit offers the only incentive for intensive long-range management. To repeat—for emphasis—if these lands were not capable of profitable production of tree crops, they would soon revert to other uses. The United States system of economic competition would so dictate.

Profits come to the tree farmer chiefly from his principal occupation, the production of timber. Multiple uses such as the grazing of livestock, leasing of rights to oil and mineral deposits, trapping of furbearers and harvesting of Christmas trees, greenery, berries and other forest by-products may also result in profits. There are some unusual examples today of tree farm land being used to produce not only logs, but fish for commercial markets, game birds for hunters and mushrooms for the gourmet's table.

On private forests, free recreation as well as other examples of applied multiple use in the public interest, are possible because the land is being properly managed for its highest use, the production of timber. Under proper management, this brings the most important link in the chain of economic forestry—profits. It is from the profit sources that public-service multiple uses are supported. All private forest management practices owe their existence to the expectation of profit.

Providing the privilege of free recreation and other benficial public uses on any land is an expense. Protecting watershed values can increase logging costs. Establishing public parks brings an initial investment as well as continuing maintenance costs; policing hunters and fishermen becomes a burden on operating expenses; and there are added costs of fire prevention and control involved with public use of forests.

As a matter of fact, intense research activity in determining the means by which an economic value can be placed on production of water, provision for recreational opportunity, and even pure scenic opportunity, as well as on the other recreational uses such as hunting, fishing, and the like, would have important long-range effect on availability in the future. If, for example, the manipulation of watershed cover through the planned harvest of timber to increase water production would bring a definite economic return to the owner of the watershed, his management activity for that phase of the resource would inevitably intensify. Water production would provide profit and water supply would increase.

As some students of the problem have suggested, it may become necessary in the future for the recreation seeker to pay his own way on both private and governmental forests.

The profit responsibility strikes equally to the heart of a manufacturing enterprise dependent on public timber supplies. Without a reasonable profit from operations dependent on public timber the businessman cannot continue to utilize the resource. All public land managing agencies have a proprietary responsibility to obtain the maximum possible long-term return for the timber or other products or services sold. They have just as important a public responsibility to assist in the long-term maintenance of a healthy, viable industry and forest community complex. This in no way implies subsidy, direct or indirect.

This relationship was brought out very clearly in the recent Report of the Secretary's Timber Appraisal Review Committee headed by Dr. Albert Worrell, Professor of Economics at Yale University. The report issued June 1, 1963 states as follows:

"The relationship between the national forests and the wood-using industry is in some respects unique. It cannot be characterized as a one-way street with all benefits flowing in one direction. There is a mutual interdependence that cannot be ignored since the sound management of the national-forest timber resource depends to a large degree upon the wood-using industry. This is indirectly recognized in the Forest Service Manual which says regarding commercial timber sales: 'This is the form of use which involves by far the greatest volume of timber. It furnishes opportunity for accomplishing the major purposes of national forest administration, such as maintaining and improving the forest and the productive capacity of the land.' (FSM 2411.51)

"The primary product sold by the national forests is standing timber and this will undoubtedly be true in the future despite a suggestion from one source that the Federal Government resolve its appraisal problems by producing and selling logs at the market place. It is through its timber sales program and through the purchases of timber by industry that the Forest Service is attempting to achieve a sustained timber yield on the lands it administers. The timber sales program also annually recovers a substantial monetary value that would otherwise be lost to decadence, disease, insects, and windthrow. This recovery could not be realized without a relatively stable wood-using industry. Furthermore, the timber sales program has contributed substantially to the construction of the present access road system that is necessary for protection, multiple-use, and over-all forest management. Industry is an essential element in this development. These factors emphasize the mutual interdependence which exists between the national forests and the wood-using industry. Neither can effectively achieve its goals independently of the other."

One final comment on the profit responsibility relates not to the natural but the human resources so essential to the health of the forest industry. It is, after all, people who need the products we produce, use the recreational resources of our lands, provide the skills and knowledge that permit us to keep pace with a fast-moving society and offer the capital and the courage to invest in the future of our companies, our resources and our society.

Profits provide the ability to research and develop new products and improve our resource management skills. Profit from the timber crops improve our abilities to more efficiently utilize the secondary resources on our lands. Profits insure stable jobs for our employees in healthy, progressive communities. Lastly, profits stimulate the critical element—incentive—for the expansion and replacement of facilities and resources, and for investment in the continuous cycle of conservation. This is our profit responsibility. It is a conservation responsibility.

COOPERATION

Our final responsibility is one of cooperation, with government agencies at every level and with individuals and citizen groups whereever our interests meet. This is vital to the concept of "Resources for the Good Life." As was mentioned earlier, achieving this goal becomes the challenge of meeting and balancing needs and desires in the most equitable fashion. In short—providing the greatest good for the greatest number. Adequate service of needs with equity, however, requires acceptance of the responsibility for cooperation.

You may be assured that our desire to cooperate in achieving mutually compatible goals is no idle comment. It is my belief that we in the forest industry have firmly established a record which indicates a sincere desire for continued cooperation. This is illustrated in concrete fashion by the millions of acres of privately owned forestland where a host of recreational opportunities are freely offered to an eager, appreciative public.

We realize there is room for a great deal more effort in the cooperative situation. Cooperation, like communication, is a two-way street. It requires resilience on the part of the opposite poles if the two are ever to have a common meeting ground. On certain specific aspects of resource management we still find rigid refusal to jointly consider problems and potential solutions to points of disagreement. This is not to suggest that rigidity is the sin of one party alone. Landowners, too, have had their blind spots.

This is to suggest that improved cooperation between industry representatives and conservation groups might smooth the road ahead. We openly acknowledge our responsibility to work for the establishment of a common forum where we may meet, discuss and hopefully narrow the gaps that misunderstandings have opened between us. I invite you to join us in meeting that challenge. That too, is a fundamental responsibility of private management of resources for *"The Good Life."*

DISCUSSION

CHAIRMAN FOX: Thank you, Mr. Orell.

I think all of us agree that you have lived up to our interpretation of you as a stateman in the field of conservation.

Do we have any comments or questions relative to this very stimulating paper presented by Mr. Orell?

MR. DAVID BROWER [Sierra Club, San Francisco]: We have been critical from time to time of your industry, Mr. Orell. However, we need the paper from your industry to carry our criticism, and so we must cooperate.

What are some of the things the people here can do to help achieve more efficient forest products production on land presently dedicated to this purpose, thus making the preservation of environmental wilderness forests possible on a generous scale in national parks and also for our more crowded future?

MR. ORELL: Mr. Brower, you have asked a very complex and complicated question. As a matter of fact, you and I have carried on a controversy at somewhat of a distance over a period of time, and I am glad to be able to answer your question directly.

There isn't any question but that we will need, in the future, to intensify the management of commercial forest lands for the purpose of growing better timber and, through genetics, grow it faster.

Your question goes directly to the heart of the problem of wilderness preservation, which is how much commercial forest timberland can be included in wilderness areas without seriously curtailing the ability to supply products for the wood needs of the nation now and in the future.

When you ask me the question as to what the public sector can do, my only answer is—research. I would have to say to you that it seems to me, and I would like to point out to you and everyone else here, that the forest industry is not opposed to wilderness preservation, and the only place where we have a controversy is in how much commercial timberland needs to be included in the buffer strips. In my own case, I worked for several years in the Mt. Hood National Forest and for two years my job was protecting Jefferson Park, a primitive area right at the base of Mt. Jefferson. There have been times when it seemed that chain saws were going to crawl their way up Jefferson Park ridge. Believe me, if that were to happen, I would be the first to be in there with my shotgun, rifle or pistol to attempt to prevent it.

I suspect I have not answered your question directly. The only thing I can say is that as income from commercial timber goes into public coffers and as economic return is enhanced, the intensity of management and research will be enhanced, and the possibility of having a reasonable amount of commercial timberland included in preserved areas for wilderness purposes will be enhanced.

Against that is the balance of increasing population and there is a conflict because with increasing populations we shall need more solitude and also more products.

NEXT MOVES: WHERE? WHOSE?

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Looking ahead, the year 1964 offers considerable opportunity for conservation achievement. Congressional reaction to conservation concepts is largely sound and sympathetic; many bills have made some progress; and interest has not dimmed in others. Most bills look to progress; only a few would do violence to conservation objectives.

In attempting to answer the question of Next Moves: Where? Whose?, perhaps a word about the past will furnish some background. On the national level 1963 was largely a year of delay and frustration though some progress was made on a number of worthy conservation measures before the Congress, and a few good bills were passed.

The tragic death of President Kennedy was a special loss to the conservation movement as he was actively supporting many of the most important concepts and measures.

President Johnson has said that he will continue the policies of his predecessor, but up to now he has been confronted with so many major problems that he has not yet dealt with these measures of deep concern to all of us.

We are hopefully awaiting his follow-up in this important public field. Perhaps the fact that he has retained Secretary Udall and Secretary Freeman, both real conservationists, in his Cabinet is a sign that he will actively support the conservation measures that they advocate.

What can be accomplished in Congress this year depends mostly on public understanding of the issues that are involved, the need for each proposal, and the benefits that would accrue. No two bills move uniformly from introduction to enactment during the legislative process. There can be spurts of progress and days of delay. The whole process, from beginning to end, is competitive for attention, time, and favor. Progress is seldom dramatic, when it comes. Legislative success, more than anything else, is the product of patience and persistence.

A prime example is the Wilderness Bill, now in its eighth year before Congress. The next move on the bill is up to the House Committee on Interior and Insular Affairs, the same group that permitted a good Senate bill to die short of enactment in 1962.

On the surface the legislative situation looks much the same as before. Again the Senate has sent a good bill to the House. Field hearings once more were held in the West, and most of the witnesses again asked for a national system of wilderness to protect a part of native America for the benefit and enjoyment of all generations. Further hearings may be held in Washington soon, possibly before Easter.

There is reason this year for guarded optimism and for more hard work. Good conservationists—Congressmen John Dingell of Michigan, Henry Reuss of Wisconsin, Charles Bennett of Florida, and others—have introduced a new wilderness bill that was worked out by the Administration to meet objections of opponents on the House Committee. This bill can be the catalyst for resolving House and Senate differences over the scope and nature of the wilderness system.

Compromise often is the price of legislative accomplishment, but it need not sacrifice fundamental principles. The Administration's draft bill, H.R. 9162 and others, would allow mining and prospecting to continue for 10 years in wilderness areas where it is now allowed. The Senate bill, S.4, would not. Mining is not an appropriate use of wilderness, particularly under the ultra-liberal provisions of the antiquated 1872 mining law. This flaw in the Administration's bill can be overcome by inserting new language that would permit mining only at times and places when the President decides it is essential to national security.

New language also should be inserted in the Administration's bill to assure that national forest primitive areas and back country in national parks and wildlife refuges will continue to receive protection pending Presidential recommendation and Congressional affirmation of their inclusion in the wilderness system. The Administration's bill is not clear in this regard.

The bill also needs to be changed to leave no question that the guidelines so carefully spelled out for national forest wilderness, canoe, and wild areas apply as well to the national forest primitive areas and parks and wildlife refuges that may be designated as wilderness in the future.

Now, to show that major conservation measures do not progress through Congress at an even rate, I turn to the Land and Water Conservation Fund bill, H.R. 3846, that seeks to link the States and Federal Government in an imaginative coalition for meeting outdoor recreation needs. A relative newcomer, compared to the Wilderness Bill, this important measure is an outgrowth of the recommendations of the Outdoor Recreation Resources Review Commission. It has been reported favorably to the House and should come up for floor debate soon.

Contradiction and outright opposition threaten the conservation fund bill. There is a contradiction because some groups object to the idea that recreationists should help pay for planning, land acquisition, and development. There is opposition because a few groups, like the inland waterways navigation interests, think the best way to protect their continued heavily subsidized free use of the nation's waterways is to kill the bill rather than to work cooperatively with conservationists for its clarification.

It is difficult to understand why anyone familiar with the facts would oppose a recreation-use fee, providing it is used to create more recreational opportunity. The Land and Water Conservation Fund would do just that. It offers a comprehensive program, capable of reaching into every community, helping the willing, and prodding the reluctant.

The funds' financing would come from three sources—the refundable, but unclaimed, motorboat fuel tax, proceeds from the sale of surplus federal property, and from entrance and associated fees at developed federal recreation areas. In one way or another these moneys now go principally for non-recreational federal purposes. Under H.R. 3846, the money would be used entirely for outdoor recreation planning, land acquisition, and development. Up to 60 percent of the money would be available for State parks, recreation, and fish and wildlife programs. Its division among State purposes will depend on the program that is devised by the State agencies themselves.

Equally important as the availability of this new money to State outdoor recreation programs is the fact that the matching requirement would stimulate State legislatures to provide additional money for recreation purposes. It is not necessary to tell the State administrators that they need more funds. They already are painfully aware of that. And they know, too, the value of a matching fund requirement to move reluctant legislators to appropriate the extra money.

Some States already have made an excellent start toward meeting outdoor recreation needs, but their number is few. These are the same States, for the most part, that usually move readily to meet the needs of their people.

Enactment of the Land and Water Conservation Fund would be a stimulus in much the same way, I believe, as was the Federal Aid in Wildlife Restoration Act of 1937 and its later companion act for sport fisheries. Tremendous progress has been made possible by those two acts, and the Land and Water Conservation Fund offers fully as monumental an undertaking. I commend this bill to your active support.

Outdoor recreation cannot endure without the natural resources that provide both its cast of actors and its stage. Clean water is one of the most important of all natural resources, and outdoor recreation is largely dependent on it. Nationally we are failing to keep waters clean, to reduce pollution reaching them, and to develop techniques to handle the newer and more complex pollutants. Nearly 6,000 communities serving 35 million people have adequate sewage treatment facilities. Many have none. A similar number of industries also lack treatment plants.

A more vigorous effort is needed at all levels of government. Research, law enforcement, sewage treatment plant construction, and other essential activities must be expanded. Amendment of the Federal Water Pollution Control Act to give the program authorized by that act a truer direction and an enlarged role in serving the public interest is of paramount importance. Bills now being considered by the House Public Works Committee—S.649 by Maine's Senator Muskie and others and H.R. 3166 by Congressman John Blatnik of Minnesota and others in the House—recommend a new national policy for clean waters. They ask Congress to reject the prevailing but antiquated philosophy that the nation's waters are a convenient broom that sweeps wastes from the doors of the polluters.

Conservationists long have been dissatisfied with the timidity and the lack of urgency that has characterized the Public Health Service's administration of the pollution control program. Practically all phases of the program reflect the Service's cautiousness and its preoccupation with public health.

The Senate bill would divide the pollution control program, and place law enforcement, comprehensive planning, and a few other small activities under a new Water Pollution Control Administration. Assignment of the other functions would be left to the judgment of the Secretary. This means, for all practical purposes, that the $100 million annual construction grants program, research, and training would remain in the Public Health Service. Once before Congress gave a HEW Secretary a blank check to improve the pollution control program's administrative stature, and he couldn't get it away from the Public Health Service. I doubt if any other Secretary would be able to do it now. Congress should make the decision.

The House bill would transfer the entire program to the new Administration. It makes little sense to divide the program as recommended by the Senate. Coordination is difficult enough within a single agency. The entire program should be in a single unit under a Water Pollution Control Administration in the Department of Health, Education, and Welfare.

Pollution of another kind, with economic poisons, is receiving more and more attention. President Johnson, in his message to Congress on health, divulged that additional funds are being requested for study of the environmental effects of economic poisons. New agreement has been reached among affected federal agencies on matters involving pesticides registration and the setting of tolerances. Congress also has changed the law to eliminate protest registration of contested poisons. All these steps are encouraging, and I hope they hasten the day when man will be able to predict in advance the results from the field application of any pesticide on any day.

Conservationists' hopes for early and amicable settlement of the long-standing controversy over the Tule Lake National Wildlife Refuge in California have been dashed by amendments to the Senate bill by the House Interior and Insular Affairs Committee. The bill, S.793 by Senator Thomas Kuchel and others, seeks to stabilize the boundaries and the administration of the Tule Lake, Lower Klamath, Upper Klamath, and Clear Lake refuges in California and Oregon.

An amazing committee amendment, which consists of a new Section 8 to S.793, would permit the legislatures of Oregon and California to veto the Federal Government's use of its own lands in the Tule Lake and Lower Klamath refuges for waterfowl conservation. If permitted to stand, this amendment could be used to eviscerate the two refuges.

In a second amendment, this to Section 6, the committee takes the unusual step of recommending that a contract between the United States and a local irrigation district be written into law. If approved, it would weaken the authority of the Secretary of the Interior to manage water levels in the Tule Lake refuge for benefit of the waterfowl. The House committee has reported the amended S. 793 and the bill may move to the floor for vote soon.

The Senate Commerce Committee recently concluded hearings on bills by Senators Metcalf, Burdick, and others that seek to overcome a serious obstruction to the $105 million emergency wetlands acquisition program. That 7-year program is lagging in the nesting grounds because county governments are objecting to the federal purchase of private lands until they are assured of annual payments comparable to amounts that would be received from taxes.

Counties currently share in the revenues arising from the sale of timber, forage, and other natural products of federal wildlife areas. The allocations are made on a revenue-generated basis, with counties receiving 25 percent of the receipts from wildlife lands within their borders. The bills would change the formula to give all counties in which private lands are acquired an annual payment ranging from three-fourths to one percent of their adjusted value. This figure is close to the amount the counties would expect to receive from taxes on lands in private ownership. The 25 percent sharing of revenues received from reserved public lands would remain unchanged. Total allocations to the counties would be limited to annual receipts from the sale of refuge products.

Objection to these bills is expected from Louisiana where one parish currently receives a large revenue payment each year because of a wildlife refuge's location over a productive oil field. That parish's discomfort may be eased by an amendment suggested to the committee that would give counties the option of having their revenue shares based either on the adjusted value of the land or on 25 percent of the refuge receipts.

The wetlands preservation program will continue to lag in the nesting grounds unless the formula for revenue sharing is revised or the veto power given the Governors over the purchase of lands in this emergency program is deleted. Another drawback has been the failure of the Congress to appropriate the anticipated annual amounts under emergency wetlands authorization. The acquisition program is ahead of schedule in the wintering grounds and along the flyways only because of the inability of the Bureau of Sport Fisheries and Wildlife to use funds freely in the nesting grounds. Appropriations provided thus far have fallen short of program projections.

Many park and recreation area bills could be mentioned, if time would permit. Such recreation areas as Ozark Rivers, Indiana Dunes, and Tocks Island on the Delaware River appear to have a chance for authorization this year. The Oregon Dunes bill also should be enacted but, unfortunately, it lacks the backing of a unified congressional delegation. Fire Island and Sleeping Bear Dunes may be destined to wait another year, although both of these are eminently worthwhile projects.

Award of a license by the Federal Power Commission to a private corporation for High Mountain Sheep Dam on the Snake River in Idaho and Oregon, clears the way for enactment of a Salmon River Sanctuary bill. FPC's decision cut down the threat of a monstrous dam at the Nez Perce site below the confluence of the Snake and Salmon Rivers. It was based largely on the lesser impact of High Mountain Sheep Dam on the Columbia River's salmon and steelhead resources.

The Department of Agriculture is continuing to press for cropland conversion and recreational development on farms under its Rural Areas Development program. This can yield long-term benefits for outdoor recreation and for fish and wildlife. Privately owned land produces 80 percent of the game taken by hunting, and has 85 percent of the wildlife habitat economically feasible of improvement. And because of the concentration of public land in the West, private land holds the key to outdoor recreational opportunity in nearly two-thirds of the country. Reports show that more and more farmers are becoming interested in the various recreation assistance programs.

The relationship between the Internal Revenue Service and the emerging spectrum of outdoor recreation on private lands requires thoughtful examination. Rural landowners, who are actively encouraged to develop and maintain outdoor recreation enterprises through a variety of federal programs, are confronted with a paradox. Some, but perhaps not all, come under the 20 percent federal excise tax on club dues and initiation fees. Swimming and skating clubs are exempt from that tax, but hunting, fishing, and other outdoor recreation groups are not.

Another matter that merits study by all State agencies is the enactment of a liability relief law for landowners who permit recreational use of their lands. About 15 States have such law, and more States definitely need them. Liability is an important factor that presently works against public recreational use of many large blocks of private lands.

Both the tax matter and the liability issue could profitably be investigated by the President's Outdoor Recreation Advisory Council.

I cannot urge too sincerely that all conservationists carefully evaluate the various proposals that have been introduced on the State and national levels regarding the ownership and possession of firearms. No responsible individual opposes logical efforts to reduce crime of all kinds. At the same time, firearms owners and users have the right and the responsibility to insist that any actions taken to reduce the incidence of armed crime hold the certainty of effectiveness without undue penalty or harassment of the legitimate user of firearms.

Before closing, I want to give two illustrations of the kind of proposals that require careful study and evaluation. Many others also could be cited, but those two will suffice for now.

The first is the proposed Atchafalaya River floodway in Louisiana by the Army Corps of Engineers. The Corps' plans involve channel dredging, construction of levees, and the elimination of the annual floodwater cycles that make the Atchafalaya Basin a tremendous producer of wildlife, fish, and furbearers. The basin's floodplain has a history of overflow during periods of high water, followed by complete dewatering except for lakes and bayous. Happening virtually every year, this water cycle produces ideal habitat for fish and animal life. The basin is used heavily by hunters, fishermen, boaters, and other recreationists.

Commenting on the Corps' proposal, the Louisiana Wild Life and Fisheries Commission has called for the development of a new concept for flood control in which "all aspects of planning and construction would be aimed at a multi-purpose use of all our natural resources rather than a plan which will accelerate the decline and eventual loss of an area so rich in fish and wildlife and recreational wealth."

The Commission recommends that if the project is constructed that the Federal Government acquire the land involved in the project area and provide for its joint development for fish, wildlife, and recreation. The Commission also asks that navigation access be maintained between the levees and that adquate structures be constructed to provide fresh water regularly to depleted areas. The Commission deserves full support in its position.

The second project is Rampart Dam, that much-talked-about Alaskan proposal for the Yukon River. As most of you know, it has not been authorized. It is merely in the high-pressure stage of promotion. Various federal agencies have conducted limited field studies, but their reports have not been released.

Rampart Dam's advocates are mostly Alaskan politicians and political hopefuls, with the usual quota of businessmen, newspaper editors, and public power proponents mixed in. They have formed Yukon Power for America, Inc., a lobby and promotional group, with the State's entire congressional delegation, Governor, assorted lesser politicians, editors, and others sitting on its board of trustees. According to published accounts, tax money—that is public funds—of Anchorage and Fairbanks already has been diverted to that new propaganda corporation for the purpose of selling Rampart Dam to Americans and to the Congress. State funds also may be used.

Lots of big claims are being made about Rampart Dam by its enthusiastic promoters—It would be larger than Lake Erie, a new recreational wonder, a fabulous source of low-cost power beyond anything the Russians have.

Here are some of the things that are known about the proposed project: It would flood about 9 million acres of the Yukon Flats that produce an average of 1½ million waterfowl a year. Moose, furbearers and other animals would be flooded out. Salmon runs above Rampart would be obliterated. The recreational lake would be frozen over 5 to 6 months of the year. The dam would take 5 years to build and the lake 18 years to fill.

Until reports are available on studies now under way, there is no known economic justification for this project. There is no assurance that it would produce prime low-cost power. In fact, its only presently known value would be to pump nearly $2 billion of tax payers' money into Alaska during the construction period.

Conservationists are not opposed to Alaskan development, but I am sure they would prefer to see solid progress rather than monuments. Alaska needs help and special consideration. Let's help the new State with a constructive program, but let's not make the destruction of Alaskas' natural resources the price of that help and consideration.

Other one-shot proposals also are being promoted in different parts of the country in the name of progress. They all bear study and careful scrutiny. You are each aware of some in your own area.

What is desperately needed is more careful advance planning with consideration for all resources and needs. We already have far too many projects that have been built or are being proposed for a single purpose regardless of the effect on other values and needs.

In conclusion, may I say that many important and worth-while bills now before Congress need national support. There are other proposals that need careful study and perhaps opposition. Each of you in your own community can do much to assist worthy legislation and oppose that which is ill-advised. This is the duty of responsible citizens in a democracy.

DISCUSSION

VICE CHAIRMAN FLOYD: Dr. Gabrielson, we want to thank you for this splendid elucidation of the responsibilities and the opportunities which each of us has here in helping to formulate the public policy. The subject which you have been talking about does have some romantic sides to it, and I suppose we could say that you have been letting us in on some of the moonlight seances in the courtship of policy formation and decision by all of us in the United States.

MR. FRANK GREGG [Citizens Committee for Outdoor Recreational Resources]: Mr. Chairman, last night, at a meeting of the Natural Resources Council, we had a discussion about the land and water conservation bill, H.R. 3846, which Dr. Gabrielson just mentioned. I was asked to provide a list of states whose governors have not yet taken a position on the bill. I would like to take just a second to read those states. The states whose governors have not expressed themselves personally are Alabama, Arizona, Colorado, Florida, Kansas, Mississippi, Montana, Nebraska, Oklahoma, South Carolina, South Dakota, Texas, Vermont, Wisconsin and Wyoming.

In addition, only eleven governors have written letters to their congressional delegations since the committee reported out its version. Many of these were written a year ago, and Members of the Council suggest that it might be useful to those supporting the bill to encourage letters relating directly to the bills' version which will be directly before the House.

MR. MEL STEEN [Nebraska]: I don't know where that gentleman received his information, especially in relation to Nebraska. However, I would like to enlighten this group. Nebraska is one of the staunch advocates of H.R. 3846 in the nation, and we urge all the rest of you to give this measure your like support.

It is probably the most important measure that has come before the American people in the last quarter century.

VICE CHAIRMAN FLOYD: I don't know whether Dr. Gabrielson would like to respond to that or not.

DR. GABRIELSON: I don't think so. I agree with him.

VICE CHAIRMAN FLOYD: We will now move to the next speaker because we are right on schedule.

It is a pleasure to introduce to you the next speaker. He is probably known best to most of you by his recent activities on the Blue Ribbon Report Studying the management of big game in national parks, Dr. Starker Leopold.

PREDATOR AND RODENT CONTROL IN THE UNITED STATES

A. STARKER LEOPOLD

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

March 9, 1964

The Honorable Stewart Udall
Secretary of the Interior
Washington 25, D. C.

Dear Mr. Secretary:

Your Advisory Board on Wildlife Management transmits herewith our second report to you, this one being on the subject "*Predator and rodent control in the United States.*"

In many ways the problems of reducing animal damage are far more complex than the relatively straightforward issue of managing wildlife in national parks, which was the subject of our first report. A large number of governmental and private organizations are involved in the control program in one way or another, and the area encompassed is enormous. We have focused attention on the role of the Branch of Predator and Rodent Control in the Fish and Wildlife Service, which is the key agency in this program and is under your direct jurisdiction. Members of the Board have traveled widely through the country, learning of local problems of animal damage and how they are handled by the Branch. We hope that the criticisms and suggestions brought out in the report are of a constructive nature, and that the proposed changes in the program are realistic and feasible.

We would like to state that in our investigations we have received excellent cooperation and aid from personnel of the Fish and Wildlife Service, as well as from many other groups and individuals. Our task was thereby made much easier.

Respectfully submitted,
Stanley A. Cain
Clarence M. Cottam
Ira N. Gabrielson
Thomas L. Kimball
A. Starker Leopold,
Chairman

PREDATOR AND RODENT CONTROL IN THE UNITED STATES

In a frontier community, animal life is cheap and held in low esteem. Thus it was that a frontiersman would shoot a bison for its tongue or an eagle for amusement. In America we inherited a particularly prejudiced and unsympathetic view of animals that may at times be dangerous or troublesome. From the days of the mountain men through the period of conquest and settlement of the West, incessant war was waged against the wolf, grizzly, cougar, and the lowly coyote, and even today in the remaining backwoods the maxim persists that the only good varmint is a dead one.

But times and social values change. As our culture became more sophisticated and more urbanized, wild animals began to assume recreational significance at which the pioneer would have scoffed. Americans by the millions swarm out of the cities on vacation seeking a refreshing taste of the wilderness, of which animal life is the living manifestation. Some come to hunt; others to look, or to photograph. Recognition of this reappraisal of animal value is manifest in the myriad of restrictive laws and regulations that now protect nearly all kinds of animals from capricious destruction.

Only some of the predators and troublesome rodents and birds remain unprotected by law or public conscience. In many localities bounties are paid for their scalps, and government hunters are employed for their control. In point of fact, there are numerous situations where control of predators, rodents, and even some birds is essential to protect important agricultural and pastoral interests or human health and safety. The problem is to differentiate those local situations where control is justified from the numerous cases where the same species of animals have social values far in excess of the negligible damage they cause. The large carnivores in particular are objects of fascination to most Americans, and for every person whose sheep may be molested by a coyote there are perhaps a thousand others who would thrill to hear a coyote chorus in the night.

Control programs generally fail to cope with this sliding scale of values. Particularly when professional hunters are employed, control tends to become an end in itself, and following Parkinson's law, the machinery for its accomplishment can easily proliferate beyond real need.

The present report attempts to reappraise the complex problem of animal control, with emphasis on the role played in this endeavor by the Federal Government. As a basis for the recommendations that follow, the Advisory Board has adopted the following tenets:

1) All native animals are resources of inherent interest and value to the people of the United States. Basic governmental policy therefore should be one of husbandry of all forms of wildlife.

2) At the same time, local population control is an essential part of a management policy, where a species is causing significant damage to other resources or crops, or where it endangers human health or safety. Control should be limited strictly to the troublesome species, preferably to the troublesome individuals, and in any event to the localities where substantial damage or danger exists.

It is the unanimous opinion of this Board that control as actually practiced today is considerably in excess of the amount that can be justified in terms of total public interest. As a consequence, many animals which have never offended private property owners or public resource values are being killed unnecessarily. The issue is how to sharpen the tools of control so that they hew only where cuts are fully justified.

EXISTING CONTROL MACHINERY

The existing organizations and programs for controlling vertebrate pests are complicated almost beyond belief. There is no single agency of responsibility. Central to the whole undertaking, and playing a major part in the control of predatory mammals, is the Branch of Predator and Rodent Control of the U. S. Fish and Wildlife Service. This Branch likewise participates under certain situations in the control of rodents, pest birds, and small carnivores carrying rabies. But this is only the beginning. Most states have control programs of their own, administered through departments of agriculture, fish and game, public health, university agricultural extension, or combinations thereof. Many county governments have rodent control programs and some conduct predator control as well. Livestock associations often contribute to control programs at the county, state and federal level. Bounties are still paid by a number of states and counties. Fortunately this obsolete practice is on the wane, but Michigan, for example, still spends nearly a quarter million dollars a year for bounty payments. Finally, there are the countless individual ranchers and farmers who take control into their own hands when they cannot get some agency of government to do the job for them.

Perforce, much attention in this report is directed to the activities of the federal Branch of Predator and Rodent Control, partly because the Secretary specifically invited comment on this activity within the Department of the Interior and partly because it is the only cohesive, organized unit whose activities touch a large part of the country. But we recognize that problems of over-control are generated in considerable part through state, county, and local programs, which all outside the legal jurisdiction of the Federal Government but contribute to the overall problem nonetheless.

The federal program of the Branch of Predator and Rodent Control (hereafter referred to as PARC) is financed cooperatively with many other agencies and organizations. In recent years the total program has expanded from about a $3 million operation in the early 1950's to approximately $6 million now, due more to rising costs than to increasing manpower. Roughly 90 per cent of the money is spent in the dozen states west of the Great Plains, from Montana and Texas to the Pacific. The proportional contribution of PARC has remained at about 40 per cent, the balance coming from other federal bureaus, state and county governments, and livestock associations. In some states, as for example, Utah and Nevada, a special head tax on sheep is assessed to supply this cooperative contribution. In others, the money comes from general appropriations. Several state legislatures have appropriated fish and game license funds for this purpose, often without the voluntary consent of the fish and game commission or department, whose funds are thus expropriated. County funds usually come from general appropriations, but in California a number of counties have been utilizing fish and game fine monies ear-marked for wildlife management. Many livestock associations contribute working funds, and some individual ranchers put up money for which, of course, they expect control on their own ranches. The whole pattern of finance is a complex one.

There are sound arguments in favor of a centrally directed federal program to which interested parties contribute operating funds. The centralized program is far more efficient in terms of proper distribution of manpower, use of relatively safe and effective control methods, and in results per unit cost. Local financial participation certainly denotes a level of interest which would not be the case if the program were completely a federal subsidy, without local investment. On the other hand, there is one substantial disadvantage to the cooperative type program, namely, that the local cooperating agencies have a major voice in determining where, when, and how much animal control is to be undertaken.

One of the first questions to which this Board directed its attention was to seek criteria which govern decisions on control. Marauding animals cause damage, and decision on control would logically bear a direct relationship to the amount of damage being caused, as expressed in dollars lost, or per cent of the lamb crop taken, or some other objective measure. We found a great paucity of such data, and in many cases they seem to play little if any part in decision making. Rather, control decisions appear to be based on the subjective judgment of PARC field men or supervisors in conference with livestock operators and agricultural officials. Some PARC administrators show remarkable discretion in encouraging only sound local programs and resisting marginal or spurious proposals, but we have abundant evidence that others willingly support almost any control proposal in which someone is enough interested to contribute matching funds. The determining criterion, therefore, frequently is a matter of finance and of "program building" rather than need.

In short, the federal predator and rodent control program is to a considerable degree shaped and designed by those who feel they are suffering damage from wildlife. Too often PARC personnel support and encourage control decisions without critical appraisal. At times they are known to solicit requests for control and to propagandize against predators as a basis for such solicitation. There is no mechanism to assure that the positive social values of wildlife are given any weight in decision making nor that control, when it is undertaken, will be limited to minimal needs.

The unilateral nature of the PARC program, and its firm entrenchment as a protective subsidy of livestock and agricultural interests, have invited criticism and distrust from many groups and individuals interested primarily in wildlife protection, including many ranchers. There have been numerous investigations and reassessments of the function of the Federal Government in animal control, of which this is only one. Essentially all have concluded, as have we, that some control is necessary and that a federal program associated with the Fish and Wildlife Service (rather than the Department of Agriculture) is the best plan of organization. But it has become increasingly clear over the years that some review mechanism is required to protect animal life against unnecessary or excessive control and to assure that the interests of the public at large are duly considered, as well as the interests of agriculturalists and livestock operators. Such a mechanism is proposed in a later section of this report.

PREDATOR CONTROL

Damage Caused by Predators.

The primary target of predator control in the western United States is the coyote, and the main purpose of coyote control is to protect domestic sheep. The total number of sheep in the eleven western states has decreased slightly in the past decade, from 12,527,000 in 1952 to 12,293,000 in 1961. Much more marked has been the decrease in numbers of sheep grazed on public land. In 1952, 8,311,000 sheep were permitted use of grazing lands administered by the Bureau of Land Management; by 1961, this number had declined to 6,696,000. During the same period, use on Forest Service land decreased from 3,006,000 to 2,491,000. The decline of the western sheep industry is due in part to low prices for lambs and wool and, in part, to increasing costs of labor, particularly involving herding. There is a definite tendency to keep more sheep in fenced pastures on private land and to send fewer flocks afield to graze under the custody of herders. Whereas the decrease in the sheep industry as a whole would suggest a lessening need for coyote control, the shift to pastured sheep without herders counteracts this, since unherded sheep are highly vulnerable to predation. In those localities where sheep are a major commodity, there is still definite need for control of the coyote population. But sheep localities are shifting from the mountains and open range to privately owned valleys and foothills.

In our quest for substantive data on sheep losses to coyotes, we obtained fragmentary records from PARC and others from Wool Growers Associations verifying that local losses sometimes are severe. But the only extended record expressing trends in the sheep industry, predator losses, and costs of predator control were obtained from four western regions of the Forest Service. The data cover the years 1941 to 1962, but we have summarized in Table 1 merely some of the pertinent statistics for the last year, 1962. It can be seen that on the national forests, at least, the total cost of control exceeds the value of the sheep lost during the summer grazing period (and it is traditional for sheepmen to charge nearly all losses to predators.) In Region V, for example, which includes 18 national forests in California, the value of sheep lost in 1962 was $3,501.00 and the cost of predator control on national forest lands was $90,195.00. Admittedly, losses would have been higher without coyote control, both on the forests and on adjoining private ranges. The issue is, how much of this control is really justified? Most of the 64,743 sheep now grazed on national forests in California are concentrated in the northern and eastern forests, yet traditional coyote control programs are con-

TABLE 1. STATISTICS OF SHEEP GRAZING, PREDATOR LOSSES, AND COSTS OF PREDATOR CONTROL IN FOUR WESTERN REGIONS OF THE U. S. FOREST SERVICE FOR THE YEAR 1962.

USFS Region	Sheep[1] Grazed	Sheep[2] Lost	Percentage Sheep Lost	Value Sheep[3] Lost	Cost of[4] Control
I	153,788	1,435	.9	$ 24,784	$ 20,044
IV	1,143,219	12,630	1.0	218,120	142,902
V	64,743	223	.3	3,501	90,195
VI	116,223	1,116	.9	19,273	37,908
				$265,678	$291,049

[1] For average period of 3 months in summer.
[2] All losses charged to predators.
[3] Sheep values figured from Statistical Bulletin No. 333 and 230, USDA Agric. Marketing Service.
[4] This figure represents cost of control work on Forest Lands.

tinuing in other areas where few if any sheep are now pastured and where recreation is acknowledged as the primary use of forest lands. On many California forests the esthetic value of coyotes greatly exceeds any potential damage that they might cause. Although the PARC program in California is exceptionally well administered, there seemingly is no mechanism for re-evaluating the goals of predator control in the light of changing public values.

In some localities, the control of coyotes is justified on the basis of protecting calves from predation. We have scant evidence as to the extent of calf predation, although it is said to be serious in certain neighborhoods in Nevada, Arizona, and Texas. In great areas of the West, cattle and coyotes seem to live amicably together, with no reported losses whatsoever. On rangelands occupied only by cattle, and not used by sheep, it is the opinion of this Board that there is little justification for general coyote control, and it should be undertaken only in localities where substantial calf losses are established on a basis of irrefutable evidence.

Poultry ranches are subject to severe predator losses at times from a variety of animals, including particularly bobcats, coyotes, and raccoons. Usually, however, these losses are highly localized and control in the immediate vicinity of a turkey ranch, or large chicken farm, effectively eliminates damage. General control programs applied over large areas are rarely justified.

Other animals taken in PARC predator control operations are enumerated in Table 2. Some of these, as, for example, most of the bears and beavers, represent individual animals that are creating pest situations. Foxes, raccoons and skunks are killed largely in rabies control operations, to be discussed shortly. Bobcats are widely killed, though the damage they cause is highly local and in many areas negligible. But a great many of the animals enumerated in this table are taken inadvertently as innocent victims of the control operation. This certainly applies to most of the badgers, opossums, and some of the bears, foxes, raccoons and skunks. Porcupines are killed to protect timber values, and this seems to be true in areas where porcupine damage does not occur as well as areas where damage is known. Additional to this list, and not recorded for obvious reasons, are the other inadvertent victims, including deer, domestic dogs, eagles, vultures, and perhaps occasionally valuable furbearers such as pine martens.

In a good many areas where there is no livestock, or at least damage is not being reported, PARC conducts predator control on the grounds of protecting native wildlife. The assertion that native birds and mammals are in general need of protection from native predators is supportedly weakly, if at all, by the enormous amount of wildlife research on the subject conducted in the past two or three decades. Predators patently catch some birds and mammals of practically all native species, and there are local situations where predator control can be justified. But it does not follow that predation is necessarily a factor determining average population levels, nor that generalized predator control is an effective form of management. In the opinion of this Board, predator control for the protection of other forms of wildlife should be undertaken only after competent research has proven it to be desirable and locally needed. Many situations have come to our attention where control is conducted on the assumption of benefit rather than on proof of need. As one example, we cite an extensive program of coyote poisoning on the Cabeza Prieta Game Refuge in Arizona in the absence of any acceptable evidence that it is needed to protect the native bighorn or any other form of wildlife. In short, some of the damage on which predator control programs are predicated may be far less serious than is purported. Much of the existing control program could be eliminated while con-

TABLE 2. ANIMALS TAKEN IN FEDERAL AND SUPERVISED-COOPERATIVE CONTROL OPERATIONS IN THE UNITED STATES, FISCAL YEAR 1963.

Predators	
Bear	842
Lynx and bobcat	20,780
Coyote	89,653
Mountain lion	294
Wolf	2,779[1]
Other animals	
Badger	6,941
Beaver	1,170
Fox	24,273
Opossum	7,615
Porcupine	6,685
Raccoon	10,078
Skunk	19,052
Miscellaneous	601
	190,763

[1] Including 2774 animals taken in Texas and Arkansas and classed as red wolves, though most may be coyotes.

tinuing to offer completely adequate protection to critical needs of livestock, poultry, and in a few situations to wildlife.

Predator Control Methods.

When control is deemed necessary, it is important that the methods chosen be precise and selective. No method is acceptable if it results in the inadvertent death of a great number of animals during the process of killing a few that are causing damage. Efficiency, selectivity, safety, humaneness, and reasonable cost are the principal criteria which we have applied in evaluating the various methods of predator control.

In the open areas of the western United States, by far the most efficient control method for coyotes is the 1080 bait station. The station normally consists of a dead animal, such as a sheep, in which compound 1080 (sodium fluoroacetate) is injected. According to PARC ground rules, these stations are to be placed no more frequently than one to a township; their presence is to be clearly announced with posters; and thirdly, they are to be established late in the autumn and picked up early in spring so that they are only effective in the winter months. They operate on the concept that coyotes travel widely in their foraging, and any point within a township (36 square miles) will probably be passed sooner or later by resident coyotes. On the other hand, other carnivores and scavengers are very much less mobile, and the only ones that may be exposed to such a station are those living in its immediate vicinity. Most of the summer carnivores and scavengers migrate or hibernate in winter. When properly applied, according to regulations, 1080 stations of this sort do an effective and humane job of controlling coyotes and have very little damaging effect on other wildlife.

On the other hand, we are aware of a good many instances where regulations are not followed and where 1080 stations are placed much closer together than they should be, excessive doses of poison are used, and the poisoned bait is not always picked up in the springtime. Abuses of the regulations are condoned in some PARC districts. Under these circumstances, considerable damage can occur to other forms of wildlife as well as to domestic dogs. However, if regulations for the placement and treatment of 1080 stations are strictly followed, we agree with PARC that it is perhaps the most efficient and one of the least damaging methods of coyote control in open lands of the western United States. But there is need for much stricter adherence to the operational rules specified in the Manual.

Two completely specific methods of coyote control are shooting from airplanes and calling and shooting on the ground. Where justified, airplane hunting can be used to take the troublesome individual animal. Calling coyotes and bobcats has come to be an important sport in parts of the Southwest, especially in Arizona. Wherever sport hunting can be utilized to reduce the numbers of damaging predators, this certainly should be preferred over killing by professional hunters. In fact, sport hunting of carnivores on a sustained yield basis is a highly desirable form of resource use.

The cyanide gun, or "coyote getter," is an effective but considerably less selective tool for eliminating coyotes. A number of other animals besides coyotes are known to be killed by these devices, and they may be dangerous to human life as well. Although we do not recommend the elimination of the cyanide gun from the control arsenal, we do strongly recommend its use with extreme caution and only in situations where more selective methods are inapplicable.

Curiously, the steel trap which is the most widely accepted method of controlling predators is one of the most damaging in the sense of being non-selective. Trapping stations baited with either scent, carrion, or both, may randomly take coyotes, bobcats, badgers, foxes, raccoons, skunks, and various lesser animals. Much of the unnecessary and unjustified killing of wildlife in the western United States is the result of the use of steel traps set for coyotes. Despite this severe limitation, the steel trap is relatively safe for human beings, dogs (which can be released), and livestock, and as such is the most acceptable method to be used in heavily settled country, where poison in any form would be dangerous. We therefore must accept its use in many situations throughout this country.

One control method for predators that we suggest be deleted entirely is the broadcast distribution of poison baits. This certainly is the least selective control method with a maximum potentiality for damage to other forms of wildlife and it seems unjustifiable under any circumstances.

Another method of predator control for which we can find no justification whatsoever is the payment of bounties. Despite repeated studies which have demonstrated the futility and wastefulness of bounty payments, a distressing number of states and counties still make such payments. Fortunately, this is one foible that the Federal Government somehow succeeded in avoiding.

Most of the methods of predator control which have been developed by PARC are found acceptable to this Board if field application strictly follows Service regulations. Firm supervision is required to enforce these regulations in all districts, not just in some of them. We take more serious issue with the extent of predator control than with the methods used.

RABIES CONTROL

Because rabies is such a terrifying disease, its discovery in a community brings consternation to the public and to government agencies as well. Among the carnivorous animals known to serve as a reservoir for rabies, some of the more prominent are wolves, coyotes, foxes, raccoons, and skunks. Where rabies outbreaks have been detected among these animals, it has been frequent in recent years to call in the control machinery of PARC on the assumption that control of the reservoir population will hasten the termination of the epizootic, or at least will reduce the danger to humans and domestic livestock. Scientific proof of this assertion is lacking. Active control of foxes, raccoons, skunks and opossums in an area of Virginia, where rabies was occurring occasionally in domestic stock, failed to offer conclusive evidence that control led to a reduction in rabies (J. Amer. Vet. Med. Assn., Vol. 1043 [2]: 170-177, 1963). Likewise, public health officials in California and Arkansas expressed to us the opinion that innoculation of domestic dogs and cats was more effective than wild animal control in suppressing rabies. Pending more conclusive studies, it can be expected, however, that severe outbreaks of rabies invariably will lead to animal control programs.

Important issues to be determined are: 1) Will reduction of populations of small carnivores actually help in controlling rabies outbreaks, and 2) at what level of incidence should control be undertaken? Individual rabid animals may be encountered from time to time almost anywhere in North America, but how many cases of rabies should constitute valid justification for undertaking a control program?

An outbreak of rabies does not ordinarily justify a long-continued program of animal control in any given locality. Outbreaks flare up and disappear in widely separated localities and may not recur again for long periods. This would suggest the desirability of PARC maintaining "flying squads" or highly mobile units designed to cope with outbreaks wherever they may occur, but avoiding the establishment of long-term or semi-permanent control programs in any given locality when the need for such control usually is ephemeral.

RODENT CONTROL

In the western United States the control of pest rodents has in times past been a major activity of PARC and local agencies as well. In some areas it is still a large operation. Pest rodents, under many situations, can have substantial impact on agricultural crops or on pasture lands. In the arid West, serious outbreaks of rodents sometimes are a direct result of land misuse, particularly overgrazing. Long-term cure for this situation is better grazing practice, since rodent control of itself is not the cure but an attempt to cope with a symptom. Nevertheless, under existing land-use practices, some rodent control is essential for continuing agricultural operation and sometimes for range reseeding and rehabilitation.

The Federal Government, through PARC, contributes to the rodent control program in most of the western states and in a few of the states of the Midwest. In 1963, PARC spread poison baits for rodent control on 260,000 acres of federal land and 1,100,200 acres of state and private land. This is a great reduction from the era of a decade ago when millions of acres were poisoned annually, mostly for prairie dogs.

This operation is supplemented each year by rodent poisoning programs conducted by agricultural departments of state and county governments and by individual farmers and ranchers. We have no measure of the millions of acres treated per year by these other agencies and individuals, but it probably exceeds the program conducted by PARC.

One of the anomalies of the rodent control program in general is its heavy dependence upon 1080 as a principal poison. Grain mixed with 1080 is a deadly bait for prairie dogs, ground squirrels, gophers and other rodent pests. However, many of the animals thus killed end up on the surface of the ground where they are readily available to be consumed by carnivores and scavengers of all sorts, leading to the secondary poisoning of this latter class of animals. Factual data measuring the inadvertent killing of innocent animals through this mechanism are sadly lacking, but there is a great deal of indirect evidence suggesting that it is important.

In 1963, PARC distributed approximately a quarter of a million pounds of treated bait for rodents, and of this amount over 150,000 lbs. was treated with 1080. It is curious that PARC will distribute great quantities of 1080-treated grain (sometimes by airplane, as in forest reseeding projects) in exactly the same areas where they take elaborate precautions in their predator control program to protect carnivores other than the target species. Secondary poisoning of scavenging animals by rodent bodies bearing 1080 can have heavy impact on small carnivores and some birds in treated areas. In many regions of the western United States where there are no sheep and where coyote damage is negligible, the coyote nevertheless has been essentially extirpated from treated areas as a secondary result of rodent control programs. In addition to coyotes and badgers, uncounted numbers of bears, foxes, raccoons, skunks, opossums, eagles, hawks, owls, and vultures are exposed to possible secondary poisoning in these programs. In some localities 1080-treated grain is used in forests to kill rodents that may be prejudicing forest reproduction with resultant exposure of many animals to the poison.

Some of the rare species in North America may be endangered by this type of program. The black-footed ferret in the northern Great Plains is nearing extinction, and the primary cause is almost certainly poisoning campaigns among the prairie dogs which are the main prey of the ferret. In the fall of 1963 two dead California condors were picked up in an area that recently had been poisoned with 1080 grain to reduce the population of ground squirrels. This operation was conducted by agricultural interests in Kern County, California. The circumstances surrounding the death of these birds suggest that the condors may have died of 1080 poisoning, acquired from eating dead ground squirrels. The condor is a vanishing species, and it is unthinkable that this sort of mistake can be permitted to recur. Some 1080 poison distributed by the Pan-American Sanitary Bureau (through a cooperative arranged with PARC) for use in the northern states of Mexico is known to have killed several grizzly bears from the small surviving remnant in the Sierra del Nido, Chihuahua. These are the last grizzlies in the arid southwestern North America.

In short, secondary poisoning of unintended victims by 1080 distributed primarily for rodents is, in the opinion of this Board, a major problem in animal control which requires regulation. It is our recommendation to the Secretary that legal means be explored to ban the distribution and use of 1080 as a poison for field rodents. As noted in a subsequent section of this report concerning research, there may be released in the near future other highly effective rodenticides which do not have secondary poisoning effects on carnivores. Until such time as these are available, we recommend that rodent control be conducted with strychnine or other chemicals which are not readily transmitted to scavenging animals.

CONTROL OF PEST BIRDS

One of the most difficult of control problems is that concerning birds which gather in great flocks and cause damage to grain fields, fruit crops, or other agricultural resources. Various species of blackbirds, for example, have serious impact on rice fields in Arkansas, Louisiana, Texas, and California and on sweet corn and truck crops in New Jersey, Delaware, Maryland, and Virginia. The introduced starling is becoming a major pest, not only in grain fields, but in livestock feed lots, in holly groves of the Northwest, and in fruit crops, particularly in western irrigated valleys. Some small birds, which are normally considered songbirds, as for example the linnet, under some circumstances can create havoc in fruit crops such as cherries. There is a growing problem of controlling flocking birds on jet airports. Crashes of passenger-carrying planes at takeoff or landing have been definitely attributed to encounters with flocks of birds.

To date, the Fish and Wildlife Service has been properly conservative about initiating mass control programs for pest birds. A good deal of study of the problem has been conducted by the Wildlife Research Branch and some experimental control has been undertaken by PARC. This Board feels that the Fish and Wildlife Service is better equipped than any other agency to assist in the development of methods to control bird damage, but we have serious doubts about the desirability or the necessity of the Service assuming a major role in actual control programs. Most depredations on crops are highly local in occurrence, are ephemeral in the sense of shifting rapidly from one property to another, and are limited largely to crops subject to rather intensive husbandry by private landowners. Under these circumstances an action program by individual farmers is generally more practical than a government control program which could not conceivably adjust fast enough to follow the day-to-day movements of marauding bird flocks.

As regards methods of controlling bird damage, we feel that much more attention should be devoted to repellants and scare-devices and less to procedures for killing birds. There is a growing field of bio-sonics which might be developed to frighten birds from vulnerable crops by broadcasting distress calls or alarm notes. Methods and equipment are still rather primitive, but considerable success has been achieved in driving away such species as starlings, blackbirds, and grackles. In many cases depredations occur during brief periods of crop vulnerability, as for example when horned larks nip sprouting lettuce seedlings, blackbirds attack grain in the milk stage, or robins descend on cherry orchards at harvest time. Much damage could be prevented by frightening the birds away during the brief danger period, and with proper methods and equipment a private farmer or rancher could attend this duty far more effectively than a government employee.

Under certain circumstances birds may have to be destroyed, some cases in point being winter concentrations of starlings in holly groves, in cattle feed lots, or around airports. But these again are local situations, best taken care of by individual owners or administrators, using methods approved and supervised by the Fish and Wildlife Service. Again, specificity of control is a primary objective.

An unusual problem of current interest is the alleged depredations on sheep and goats by golden eagles in western Texas. Livestock operators have complained bitterly about losses which they attribute to eagles, and in years past substantial numbers of eagles have been shot from airplanes under subsidy paid by the ranchers. At the same time, the golden eagle is one of the most interesting of American birds of prey, and the winter concentration of these birds in Texas represents a substantial segment of the population occupying the west-central portion of North America. Current federal regulation protects all eagles from persecution, and although this Board has not intensively studied the problem in Texas we urge the Secretary to continue the protected status of the eagle until the facts of the case are thoroughly understood. With adequate knowledge, many vexing problems of depredation have been alleviated by methods other than wholesale killing.

To summarize our recommendations on bird control, we envisage the role of the Federal Government as primarily research, extension, and regulation of methods rather than actual control.

RESEARCH ON CONTROL METHODS

The U. S. Fish and Wildlife Service maintains two wildlife research centers, one at Patuxent, Maryland, and the other at Denver, Colorado. Much of the research directly concerned with the control of pest animals is centered in the Denver Laboratory in two sections, one concerned with Biochemistry and Pesticide-Wildlife Relations, and the other with Control Methods. A number of other agencies are involved in research on animal control, including state universities and state departments of agriculture, public health, and fish and game. But the Denver Wildlife Research Center is far and away the most important single institution concerned with predator and rodent control.

Among its many functions, one of particular concern in relation to this report is the search for more effective methods of preventing animal damage and for more specific methods of animal control. Thus, chemical compounds produced in industrial research laboratories are constantly being tested as to their toxicity to animals and their possible use as repellants or as controls. There is being tested at the present time a formulation known as DRC 714 which shows promise of being highly toxic to rodents, with a low toxicity to birds and carnivorous mammals. If this, or some other formulation, can be found which will be an effective poison for rodent control without danger of secondary poisoning to other animals that consume the bodies of the poisoned rodents, a great stride forward will have been made. Additionally, the Center is working on the possibility of developing birth control methods that may effectively limit a population of a pest animal such as the coyote without the necessity of killing any individual. Thus, the chemical stilbestrol which in very small oral dosage is known to preclude reproduction in ranch mink, is showing some signs of being effective also in eliminating litter production among female coyotes. Possibly the application of stilbestrol baits during the coyote breeding season in areas where coyotes must be controlled could be a way of accomplishing the objective without causing the death of any animals, coyotes or others.

Another area of investigation which has been pursued intermittently at the Denver Center is the study of predator-prey relations, particularly those involved between coyote populations and pest rodents. The continuing argument about whether coyotes and other predators really regulate rodent populations has been conducted over the years with more heat than light, and only now the Denver Wildlife Research Center is bringing its skills to bear intensively on this problem. Rodent populations are being compared on sites where coyotes are controlled and other sites without control. Past and current studies suggest that rodent populations, like game populations, are more a function of habitat conditions than predator pressure.

There are other areas of research which are not at the moment being undertaken by either the Denver or Patuxent laboratories and which this Board feels may be important. One is a study of rabies outbreaks in relation to the control of small carnivores that act as reservoirs of the rabies virus. A great deal of animal control is pursued on the basis that it is necessary in the control of rabies, but the facts regarding this situation are scant indeed. It would seem most appropriate for the federal research centers to undertake the study of this problem, perhaps in conjunction with public health services of either state or federal governments.

Another line of research that would be important in evaluating the control program of PARC is a socio-economic study of cost-benefit ratios of the predator and rodent control programs. Again, these control campaigns are being conducted on the tacit assumption that they create important beneficial results, but no one has actually measured the results in terms of social and economic gain, as evaluated against cost. Such an approach would have to attach positive consideration to the esthetic, recreational, and ecologic values of animals as well as to measure the negative and destructive values.

We further recommend that the research program shift some of its attention from methods of killing animals to ways of preventing depredation by repelling, excluding, or frightening animals. In the case of ducks, quail, pheasants, deer, and other game species ways have been found to reduce crop and garden depredations by means other than wholesale killing, although local control sometimes is a final necessity. With ingenuity, perhaps the same objective could be achieved, at least in some situations, in alleviating problems caused by coyotes, foxes, bears, eagles, blackbirds, and other troublesome non-game species.

Lastly, we urge a thorough and unbiased study of the economic status of the golden eagle, particularly in its relation to the sheep and goat industry. There is need for much more knowledge about the true effects of predation on sheep and goats and a better understanding of the relationship of predation to range conditions, general health of the livestock flocks, and to the variable of weather. We also need much more information on the natural history and population dynamics of the eagle.

These are only a few of the research projects that need to be pursued and are highly pertinent to the questions being dealt with in this report. We are gratified to note a substantial growth in the technical staff of the Denver Wildlife Research Center in the period between 1958 and 1962. Because of the importance of the research work, it is the hope of this Board that the Denver laboratory and the Patuxent laboratory in the East as well, can continue to obtain additional support to carry on their functions.

RECOMMENDATIONS

1. *Appointment of an Advisory Board on Predator and Rodent Control*

Our first recommendation is that the Secretary of the Interior appoint an Advisory Board on Predator and Rodent Control which will be a continuing body comparable to the Advisory Boards on National Parks or Water Resources. Such an Advisory Board should include carefully selected individuals representing the livestock and agricultural interests, conservation organizations, and technical organizations such as the National Academy of Sciences, American Society of Mammalogists, American Society of Range Management, and The Wildlife Society.

The Board would be advisory to the Secretary and would serve the important function of being a forum for the wide spectrum of opinions regarding where, when, and what animal control should be under taken. It is not expected that such a diverse group would always reach a concensus. But at least the Secretary would be made aware of sensitive problems and divergent viewpoints, which at present he is not.

As the situation stands now, appeals of all sorts regarding animal control programs are referred to the Fish and Wildlife Service and generally thence to PARC. If the appeal is for more control in a given locality, a sympathetic audience is assured. If, on the other hand, the plea is one of complaint against excessive control the PARC reacts defensively, and as a rule the complaint is stifled in one way or another. There exists no unprejudiced, objective body that receives and weighs these diverse views and opinions and that can advise the Secretary on the pros and cons of difficult issues. Although final authority regarding the regulation and management of animal control programs should remain with the Secretary of the Interior, we feel that an Advisory Board would keep him far better informed than at present about the diverse social values involved in various control cases and how these should be handled in the interests of the American public as a whole.

2. *Reassessment by PARC of Its Own Goals.*

Our second recommendation is that the Fish and Wildlife Service and its Branch of Predator and Rodent Control completely reassess its function and purpose in the light of changing public attitudes toward wildlife. There persists a traditional point of view that the PARC operation is responsible primarily to livestock and agricultural interests, and that the growing interest of the general public in all wild animal life, including predators, is a potential obstruction to the progressive control program and is to be evaded and circumvented wherever possible.

In point of fact, the segment of the public interested in husbandry and wise use of all animal resources represents a substantial majority and can no longer be suppressed. Even in farming and ranching communities there is a growing reaction against unwarranted killing of animals not actually creating a problem. A clear example is the organization of the Toponas Valley Grasslands Association in central Colorado. Ranchers in an area of 350,000 acres formed an association to protect coyotes and smaller carnivores from poisoning by the PARC. Another symptom of change is the introduction in the House of Representatives of H.R. 9037 by Mr. Dingell, on November 6, 1963. This bill clearly defines the positive values inherent in populations of wild carnivores, and to protect these values proposes to strip PARC to a skeleton crew whose function is extension rather than actual control. Unless the government control program undergoes a drastic and critical internal revision of operational objectives and procedures, an even more drastic revision will sooner or later be forced by the public, with possible serious curtailment of the control functions which we concur are locally important.

As stated early in this report, the goal of PARC should be to control animal damage on an absolute minimum basis consistent with proven needs to protect other resources and human health. Control that exceeds minimum is contrary to the public interest, and in the long run may prove contrary to the interests and even the continued existence of PARC.

3. *Suggestions on PARC Operations.*

On the open grazing lands of the West we feel that the present form of PARC organization is the most efficient form of predator control. But there is need for explicit criteria to guide control decisions, something that we find sadly lacking at present. Under properly enforced regulations and constraints the team of trained professional hunters can certainly achieve control with maximum efficiency and potentially with minimum damage to other values. Likewise, we acknowledge the necessity of continuing the cooperative program in which at least 50 per cent or more of control funds are supplied from non-federal sources. On the other hand, the justification for each local control program should be documented far better than at present, and such proof of need should be available when requested by the Advisory Board or the Secretary. The mere appeal for additional control by local groups of ranchers or the offer to help pay for a control program by a county or state is not of itself deemed justification that the program should be undertaken. As a form of justification, narrative descriptions of damage should be supplemented with quantitative statistics on the true extent of damage.

On the farmlands of the Midwest and East the need for federal control personnel is far less clear. We see little justification, for example, for the ambitious PARC program in Arkansas. In Missiouri, Kansas, and a number of other agricultural states, extension trapper specialists are utilized to work with farmers and teach them how to cope with their own problems of predator and rodent control. We would recommend therefore that in the eastern half of the United States (generally from the Atlantic westward to approximately the 98th degree longitude through eastern North Dakota and eastern Texas) the plan of government control personnel be supplanted with a program of federal extension trappers to be stationed in those states that request such coöperative service. Costs should be met on a matching basis with the states, and it is our strong recommendation that state funds be drawn from general appropriations in support of agriculture and not from Fish and Game license money. We further recommend that such extension programs be developed to replace rather than to augment bounty systems which are completely futile and unnecessary components of predator control.

Lastly, there should be maintained in the eastern portion of the country flying squads of federal control agents whose particular function is to deal with mammalian populations in areas where severe rabies outbreaks or other similar problems develop. We see no proven need at the present time for permanently established and entrenched programs of rabies control when rabies seems to be such an ephemeral disease in the wild.

4. *A Greatly Amplified Research Program.*

A well staffed and strongly supported research program can greatly enhance the effectiveness of the federal endeavor to minimize animal damage. For many years research in this area was given little attention by the Fish and Wildlife Service. We note with satisfaction the recent increase in support of the Denver and Patuxent laboratories, but this can be further extended with profit and ultimate savings to the government. We particularly would like to see emphasis on (1) finding more specific controls for pest species, thereby minimizing unnecessary killing of innocent animals, and (2) development where possible of repellants, fences, and scare-devices which would preclude the necessity of killing any animals. The research could well be financed out of savings resulting from curtailment of the present PARC program.

5. *A New Name for PARC.*

We have suggested a number of changes in basic policy and philosophy of the Branch of Predator and Rodent Control. Another name for the Branch might better express this new concept, both for the public at large and for the personnel concerned. Although control will continue to be a major function of the Branch, there is implied a much broader responsibility for management of animal life in ways other than killing. We therefore recommend that consideration be given to the selection of a new name for PARC that clearly connotes a broad management function.

6. *Legal Controls Over the Use of Poisons.*

As stated earlier, much of the damage to wildlife that is accruing at present from control operations seems to occur in the form of secondary poisoning following 1080 programs against rodents. At present there is no legal machinery to prevent a county or municipality from acquiring and using 1080 in any way it sees fit. The regulations state merely that 1080 cannot be distributed to individuals but can be purchased and used by any authorized government agency. We see no way to regulate the damage caused by many local rodent control poison campaigns, other than through strengthened federal law and procedure governing the use of these poisons. The situation is parallel in some ways to the problem of regulating careless use of insecticides. There are rigid rules guarding public health and safety, but the safeguards against ecological abuses are weak and ineffective. We recommend to the Secretary of the Interior that this question be explored with the Federal Pest Control Review Board. The purpose should be to regulate the distribution and use of 1080 or any other poison capable of having severe secondary effects on non-target wildlife species. We further recommend that the legal regulation be extended to exclude the export of 1080 to Mexico, or any other foreign country, where the danger of misuse is substantial.

SUMMARY

Federal responsibility for minimizing animal damage is properly assigned to the Fish and Wildlife Service. But the program of animal control, under the Branch of Predator and Rodent Control, has become an end in itself and no longer is a balanced component of an overall scheme of wildlife husbandry and management. In the opinion of this Board, far more animals are being killed than would be required for effective protection of livestock, agricultural crops, wildland resources, and human health. This unnecessary destruction is further augmented by state, county, and individual endeavor. The Federal Government, it would seem, should be setting an example in the proper scientific management of all wildlife resources, with a view to total public interest and welfare. Instead, the Branch of Predator and Rodent Control has developed into a semi-autonomous bureaucracy whose function in many localities bears scant relationship to real need and less still to scientific management.

It is our recommendation that there be a complete reassessment of the goals, policies, and field operations of the Branch of Predator and Rodent Control with a view to limiting the killing program strictly to cases of proven need, as determined by rigidly prescribed criteria. Where control must be undertaken, as for example of coyotes on important sheep ranges, the operation should be precisely accomplished, under close supervision, with minimum danger to non-target species. Some of the funds saved in this belt-tightening process could well be devoted to research on better and more precise methods of alleviating damage. An Advisory Board on Predator and Rodent Control, appointed by the Secretary of the Interior, is suggested as one mechanism for assuring consideration of total public interest in this program.

DISCUSSION

VICE CHAIRMAN FLOYD: Dr. Leopold, we do appreciate this splendid discussion on a current and controversial subject.

MR. CARL BUCHHEISTER [National Audubon Society]: We wish to commend Dr. Leopold and the entire committee on this very fine and historic report. We are delighted that the committee has declared the principle that predatory animals and birds are valuable parts of our wildlife.

MR. J. R. BRODEN [Vice President, National Wool Growers Association]: I assume that Dr. Leopold would be disappointed if he did not receive a complaint from the livestock interests on this report. I have listened with a great deal of interest to the report and of some of the impressions that have been left, I am quite highly critical.

I would like to quote for your benefit a letter from Secretary Udall to the National Wool Growers Association, dated August 6, 1963, in answer to a letter pointing out that no livestock interests in the West were represented on the Board that was to make the report. I might say that the National Wool Growers Association was established in 1865. In his reply to this letter, Secretary Udall stated as follows: "I will make sure that this committee makes a special point of meeting with representatives of the western livestock industry before submitting the report. In addition, we will keep you informed about the progress of the committee's report."

Now, in view of the fact that there has been no such liaison to my knowledge or to the knowledge of our organization, we would like to withhold making an official comment on the report until our Executive Committee has had an opportunity to review and study the report.

There are some phases of his report that I do favor personally. I think it would be well to have a National Advisory Board set up as a continuing body, wherein livestock interests were represented. Certainly, as an indication of the statements made this morning, livestock profits have to come into operation here and I might also say for the benefit of those assembled that the decline in livestock numbers in the West has been as much a result of difficulty in predatory animal control as to some of the other factors that are represented.

Now, I cannot let go from this meeting the statement or impression that was made in this report, wherein, if I am correct, you said that on four national forests the damage to livestock was $3,500 and where the control costs were some $90,000.

DR. LEOPOLD: That is confined to one state, California.

MR. BRODEN: I would like to bring you the other side of the coin and that is that in connection with the use of my own land, as well as in connection with some other small portions of various forests in the State of Utah, it is in excess of $3,500 per year. It costs me some ten to twelve thousand dollars in private funds to implement the present predatory animal program, which is a cost to be figured on 10 per cent of my lamb crop and would aggregate some twenty-five to thirty thousand dollars.

I want to bring this to the attention of the people assembled here because I cannot let that impression stand.

Another thing where the committee was quite critical (and these are my own views as I explained before) is that the bounty system in the State of Utah works very well, and we are pleased with it. The only thing is that we do not have enough bounty funds to handle predators. I agree with the need to assess the whole predator animal program, and I think we need more liaison and better understanding between the livestock groups and the wildlife management groups. I think this will help us all.

DR. LEOPOLD: May I attempt to answer one or two of your points?

In the first place, we had a great deal of local liaison with the Wool Growers Associations, not with the national organization, but with local state and county groups. I think we are quite aware of their problems and I stated in the report that some of the fragmentary data we had on losses were obtained from the Wool Growers Association. Therefore, though we perhaps erred in not officially contacting you and the national organization, we most certainly were not ignoring the point of view of the livestock interests.

Now, it is our hope that on this proposed advisory board your interests will be just as well represented as the conservationists, and this may be the point where effective liaison can occur.

MR. RAYMOND HALL (Kansas): It seems to me it would be better to have the central agency concern itself with research and recommendation rather than with actual service. Bill H.R. 9037 recently introduced by Congressman John Dingell corrects this particular point as I see it. This bill has the support of the Defenders of Wildlife, which I represent here today—a diverse group of increasing and large membership.

The other 96 per cent of the report, in my opinion, is extraordinarily excellent, and it seems to me that the committee deserves to be congratulated. I also think that Secretary Udall ought to be congratulated for having appointed such a fine committee.

VICE CHAIRMAN FLOYD: The response of the group, I think, indicates the quality of our presentations this morning.

Before recessing this meeting, I would like to call your attention to the fact that copies of Dr. Leopold's paper may be obtained by writing the Office of Information, U.S. Fish and Wildlife Service, Washington 25, D. C.

GENERAL SESSION

Wednesday Afternoon—March 11

Chairman: Richard A. Harvill
President, University of Arizona, Tucson

Vice-Chairman: Harry R. Woodward
Director, Game and Parks Department, Denver, Colorado

WHERE DO WE STAND?

REMARKS OF THE CHAIRMAN

Harry R. Woodward

The session this afternoon has for its theme, "Where Do We Stand?" We have heard some most excellent papers and programs in our first general session and in all of the technical sessions, and we have arrived at the point of analyzing the whole picture of what has been said in the course of this meeting.

Frankly, I know that we all know that we are not standing—that we are running—we are running because we do not have the opportunity to do otherwise.

With the population explosion that is taking place, with the dynamic situation that faces us in our own nation and in our leadership in the world, we obviously cannot stand still. I suppose you might liken our position to a group of sailors in a rowboat in an open, stormy sea—there isn't any room for anyone to lay back on the oars.

We have been fortunate during the past several years to have had a Secretary of the Interior who has served as our helmsman, who has been telling us to pull and to pull hard and to follow the example that he has been setting. Certainly, the example he has set for all conservationists has been a great one.

He has set this example through action and through words. Unfortunately, the Secretary is not able to be with us today because he has been sent on a special assignment as an emissary of President Johnson to the Government of Venezuela. We certainly can understand why President Johnson has selected our congenial Secretary. We certainly wish him well in his duties there.

Also, unfortunately for you today, Dr. Harvill, the President of the University of Arizona, who was to have been the session chairman, was unable to be with us. He has had to appear before a legislative committee for a hearing. He has sent his apologies to all of us and his very best wishes for a good session this afternoon.

We are fortunate this afternoon in that Secretary Udall has selected a very good friend of ours from Minnesota, Sig Olson, to deliver his address.

Sig, of course, as we affectionately know him, is a lifelong conservationist; a champion of the things we are all interested in. He has dedicated his life to this work as a Professor and as Dean of the Ely Junior College in Ely, Minnesota, where he was an ecologist and biologist as well as an administrator.

He has explored much of the northern part of North America and has gone far into Canada. He has taken canoe trips through those areas of northern Canada such as the Churchill River and from his experiences, he has likewise written several books and papers. Of course, he is also well known as a lecturer.

Sig is now a conservation consultant to the Secretary. He also serves as a consultant to the National Park Service, the Izaak Walton League and, further, he is a member of the Advisory Board on National Parks and Historic Monuments. He also is a member of many other special boards within our government.

In view of his tremendous experience, it is very fitting that he should be here today to bring us the Secretary's message.

WHAT PRICE RESOURCES FOR THE GOOD LIFE?

THE HONORABLE STEWART L. UDALL[1]
Secretary of the Interior, Washington, D. C.

If one reflects on the conservation history of this country, one realizes that it has been characterized by a steady stream of conservation defeats that the land has suffered at the hands of "civilization," a powerful juggernaut that ground its way across the continent, leaving in its wake destroyed habitats, endangered species of birds and mammals, polluted streams, and scarred landscapes.

Near the turn of the century we hear the voices of great crusaders like Teddy Roosevelt, Gifford Pinchot, and John Muir. They warned and pleaded and fought, and won the first great battles. The conservationists of today have inherited their vision, and our country owes much to their efforts: the preservation of our most striking natural wonders, the protection of wildlife, and most of all, the stoppage of the grievous resource desecrations. But in the process, the conservationist has been regarded as a sort of odd fellow in the popular mind: as the check-shirted, dungareed nature lover, shaking his fist like Prometheus at the onslaught of civilization.

Since Teddy Roosevelt made his first move on the most outrageous resource pillages, much has happened in this country. The population boom has descended upon us, adding over 100 million people to our population in little over 50 years, and promising to add another 110 million in the next 35 years. America is no longer a land of vast grassy plains and unexplored mountains. It is a settled, subdued land where all habitable areas have become the potential domain of the developer. Roads have stretched like tentacles across the land, bringing every corner of the continent closer to the centers of human commerce. With roads have come more settlers, more cars, more houses and soon the need for more roads. In short, America has become subject to a law of "never ending development" which spurred by the inexorable population increase, appears to be incontrovertible.

Amid this ferment of change, modern conservationists are faced with a far wider range of problems. The great battle of conservation in the sixties, the seventies, and the eighties, and in the coming century is no longer solely in the preservation of the spectacular. The real conservation fight of the future lies rather in every nook and cranny of this country where total destruction of nature, or the uglification of the countryside, or the contamination of it, is threatened

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[1]In the absence of the author, this paper was presented by Mr. Sigurd F. Olson.

by the overdeveloped, undersensitive strongmen of our society. The fight is, in short, for the creation of a livable total environment.

The real challenge to conservation now and in the future is to project itself into the main stream of American life; to make the conservation element a vital part of every decision which affects the environment in which Americans live. This means conservationists must widen their scope. Fights for the preservation of open space, for tasteful architecture, for beautiful cities, for efficient mass transportation, for clean water must be carried with as much vigor as the fights for wilderness, outdoor recreation areas, wildlife refuges, and superlative scenery.

Civilization is here to stay, and the issue now falls upon how civilization will order itself. It becomes the responsibility of conservationists to impress upon civilization the absolute necessity of using the limited amount of land that we have in the wisest possible manner. This requires not an anti-civilization attitude, but rather an attitude that not only recognizes the cultural potential of civilization, but also the possible tragedy of it, if we do not make provisions for life-promoting values.

The preservation of wilderness and wildlife become all the more important in the crowded modern context. Three quarters of our population is now urban in its residence and viewpoint. A clean slice of sky and the chance to watch a pronghorn on the run are no longer taken for granted by the city man. He has a voracious appetite for outdoor recreation, a hunger for solitude, and has developed an intense interest in preserving the natural qualities of his public land estate, as evidenced by the huge swell of public support over the last few years for the Wilderness Bill.

And this appetite will not decrease in the future. We must remember that the coming decades are bringing increased leisure time, and a greater opportunity for the individual to develop mind and spirit than was possible when long working days left little time or energy for non-vocational matters. Our word "school" derives from the ancient Greek term for "leisure," and what greater school is there for one's leisure time than the out of doors!

It is perhaps a sad commentary on our cities today that Americans need an escape into the solace and fascination of the natural world. I am hopeful that some day we will build the kind of cities which do not compel escape, beautiful cities which people will love and cherish, and when that day comes, wilderness areas will be able to stand on their original conception: as America's tribute to the wonder of nature, and her ethical regard for the inherent right to life of all things.

The simple fact is that if we are going to achieve a balanced environment, tremendous investments will have to be made. For many this will require sacrifice, the benefits of which will not be immediately apparent, but which are essential if our heirs are to have a rich life.

The task of this generation is to set the framework for sound growth. I sense that the American people are becoming aware of the larger conservation challenges and are willing to take the steps necessary to achieve a better environment. Let me enumerate, for a moment, some of the specific proposals to meet this responsibility:

Open Spaces: A cardinal rule of any balanced environment is that there should be a harmony between man's creations and nature's. As Lewis Mumford has said, "Our cities should be of the country, not in the country." If our urban and suburban areas are to become meaningful places for human habitation, enormous open space conservation efforts are going to have to be made. Even our best achievements to date have not even begun to counteract the wave of nature destruction that is engulfing the urban environment of this country.

Every month of delay is marked by spiraling land costs in our rapidly growing communities. The Federal Government is currently investing over a half million dollars to acquire easements on 46 small acres of scenically priceless land on the Potomac River palisade, adjacent to the Nations' Capital. If this seems an extravagant price tag, it is only an indication of the growing awareness that in a crowded urban setting, natural things are virtually priceless in their public value.

President Johnson has recognized this need in the expanded open space grant program which he recommended to Congress. The fine work of many citizens groups has shown what can be accomplished when sensitive people organize on the local level to demand a green legacy for their descendants.

Future Park and Recreation Areas: It is the task of this generation to establish adequate recreation areas in every one of the fifty states, and nationally, for the people as a whole. Pending before Congress is a Land and Water Conservation Fund Bill, which will provide a fair system of financing for these vital acquisitions. I cannot overstress the importance of this measure, if we are to achieve an adequate park and recreation system throughout the country.

Another conservation investment of great significance—and one that does not incur any financial outlay—is the pending Wilderness Bill which will give the sanction of law to our traditional park, forest, and refuge preservation policies.

The early national parks came from lands still within the public domain. Now with much of our scenic resource in private hands, Congress must buy back such lands to establish new parks—seashores and recreation areas—a trend of significant public investment that will continue.

Private philanthropy, for the last 50 years, has undertaken the preservation of groves of coastal redwood trees and has done a magnificent job without federal funds. These groves, repeatedly marred by the forces of civilization, are not large enough. If the American public, however, decides it wants the ecological security of a Redwood National Park, we must consider the purchase of high-quality woodlands at commercial timber prices. Public investment in the final habitat of a gigantic forest species, or rare bird such as the whooping crane, is comparable in uniqueness to investments in a Stradivarius violin, or a portrait by Rembrandt. On the other hand, if a great natural species is destroyed, no amount of genius that man can muster will be able to recreate it.

Pacific Southwest Water Plan: No resource is in more critical supply in the Southwest today than that of water. Unless this area is prepared to close its borders today to any future population growth, additional water supplies will have to be developed. The Pacific Southwest Water Plan of the Department of the Interior is a regional plan designed for maximum Lower Basin water development.

The $3 billion budget of the Plan, however, includes many associated benefits such as fish and wildlife conservation, public recreation developments, and scenic protection.

Public Land Investments: The increasing demands upon basic resources of forest, soil, water, range, fishery, and recreational land make imperative the classification and intensive management of public domain lands. As a nation, we can no longer afford to let the use of these lands develop on a random basis. We must be willing to make administrative investments in intensive multiple-use management if we want modern well-evaluated conservation programs.

In the last fiscal year $64 million in accelerated public works funds were applied to the Department of the Interior's conservation projects of which $11 million was spent by the Bureau of Land Management. A backlog of over $20 billion in much needed conservation work exists on federal lands, if they are to be brought up to productive standards within our scope of conservation knowledge. The public may not be ready to make a $20 billion capital investment in land improvements today, but it is time we began to ask ourselves how long we can afford the luxury of deteriorated range, eroded hills, polluted streams, and second-rate recreation facilities.

Human Resources: The late President Kennedy repeatedly discussed investments in education as one of our most vital conservation tasks. President Johnson is carrying human conservation another important step, by asking the country to invest in the rehabilitation of its poor and neglected citizens. The first element of his poverty program will be a youth education and training measure that can restore a sense of worth and accomplishment to young men and women who have slipped out of an active role in their society.

Of special interest to this group is a poverty program in Appalachia, where strip and auger mining have ruined wildlife habitat and destroyed fish life by polluting streams. A promising approach to environmental improvement is to use congressionally appropriated fish and wildlife restoration program funds for the important work of local rehabilitation.

Environmental Research: Our prodigious technology has created a host of chemical substances that are alien and destructive to the living forces of the environment. "It is ironic to think that man might determine his own future by something so seemingly trivial as the choice of an insect spray," Rachel Carson has observed. Yet, we have these deadly powers and know awesomely little about their side effects, particularly upon humans and wildlife. Only investments in research can solve some of these riddles and develop safer products, and we who recognize this imperative must overcome the prevailing notion that research is only a luxury.

I have left out many significant investments by focusing upon these few categories, but these are symptomatic of the depth of public involvement that will be required to meet the challenges of our national growth.

There is another form of investment which it is appropriate to emphasize today, because of the nature of this meeting, and that is an intellectual investment in some of the resource challenges of our complex times. Professional conservationists who have vision, and the ability to articulate it, have never had a larger opportunity than they do today. We can scarcely imagine what our conservation outlook would have been, had not Rachel Carson undertaken to tell America the hazards of *Silent Spring*. Only recently the Department of the Interior has received a fine analysis from the American Association for the Advancement of Science on the need for unmodified natural areas, and we are now considering a program of natural area establishment throughout our land jurisdictions.

Some of the most expert and definitive conservation thinking of our times has been done by a group of five men who need no introduction to this audience. A year ago the Wildlife Advisory Board cleared away any misconceptions surrounding the issue of public hunting in the national parks, and went on to give fresh insight into the ecological management purposes of our parks.

Two days ago you heard the Report from this same body on Predator and Rodent Control programs. I do not wish to minimize the care with which a major shift in policy, such as the Report recommends, must be undertaken, but I do wish you to know my high regard for the farsighted vision of the Report. Despite scientific evidence to the contrary, for too long we have tended to think of predators as the juvenile delinquents of the biosphere, rather than citizens with a clear claim on the right to live.

Too often, when a wildlife species is crowded to a single corner of the globe, as has been the case with the whooping crane, the California condor, and the bald eagle, we begin a flourish of gestures to protect its final habitat. There is something pathetic about a nearly-extinct creature. We can only partially applaud ourselves for halting it on the brink of extinction. Is scarcity to be our only standard of value for wildlife? The real task, it seems to me is to see that great animals, such as the grizzly, and the wolf, have an adequate—an abundant—habitat where they can fulfill their primitive lives.

These are some of our immediate opportunities to progress towards a new and higher land ethic that can cope with the revolution of the modern age. All of these measures, in the final analysis, are related to the continued material and spiritual well being of the American people. Without these higher conservation achievements America may expect a confused and unhealthy future.

Environment, we must never forget, breeds a state of mind in its inhabitants. A land which demands beauty in its architecture, refinement in its developments, wisdom in its resource handling of open space in the midst of its densely populated areas, and the preservation of large and beautiful wilderness areas will be a land which dispels prejudice and hate and fosters happiness and richness as its way of life. It is this kind of land and this type of people which should be our goal.

A Greek philosopher said long ago—"Life is a gift of nature but a beautiful life is a gift of wisdom."

Let us hope for the wisdom we need to preserve an environment in which a beautiful life is possible.

STRENGTHENING THE BIOLOGICAL FOUNDATIONS OF RESOURCE MANAGEMENT

PAUL J. KRAMER
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The necessity for better management of our natural resources becomes more apparent every year as the rapidly increasing population makes increasing demands on them. Better management requires better definition of our problems and better research to solve them.

Management of natural resources involves an extraordinarily wide range of problems, including those dealing with soil, water, minerals, animals, and plants. It also includes economic and sociological considerations such as the relative importance of land for recreation versus agricultural and other uses, of wilderness areas versus highly developed recreation areas, of flood control versus fishing, etc. However, a large fraction of the research effort in conservation goes into biological problems, particularly the protection and maintenance of populations of desirable plants and animals and many of those who work in this field are really biologists.

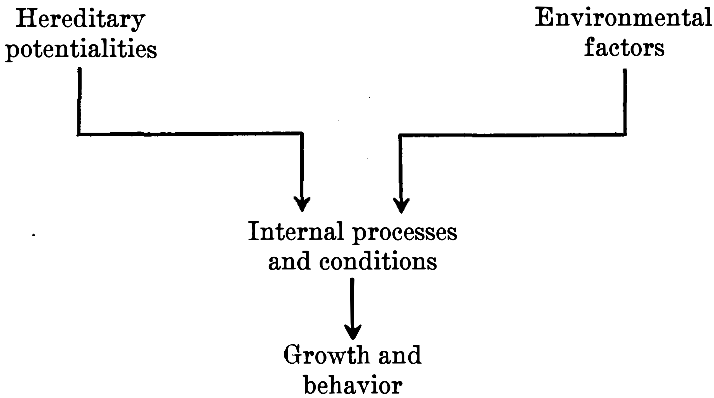
CHARACTERISTICS OF RESOURCE MANAGEMENT RESEARCH

Much of the research in resource management deals with applied, practical, or "how-to-do-it" problems. Effective solution of many of these practical problems depends on a foundation of basic information about the environmental requirements, life histories, and physiological processes of the organisms with which the investigators are concerned. I tell my forester friends that they cannot grow trees efficiently until they understand how trees grow. Likewise, you cannot manage wildlife unlescs you understand how it lives.

Perhaps I can make this argument more clear by emphasizing some basic biological principles which are so obvious that they often are ignored. It is generally understood that the behavior of an organism is controlled by the interaction of its heredity and its environment. It should be further emphasized that the only way an environmental factor can affect the behavior of an organism is by modifying some of its internal processes or conditions.

This can be shown by the accompanying diagram.

The only way an environmental factor such as light or temperature, a cultural treatment or management practice, an insect or a fungus can affect the behavior of a plant or animal is by affecting its internal physiological and biochemical processes and conditions. Thus to un-



derstand how the environment affects living organisms, we must learn how it affects the processes which are essential to their existence.

I can illustrate the application of these principles by two examples.

Many years ago when foresters first began to manage the pine forests of the Southeastern Piedmont, they attempted to maintain pine by selective cutting. This proved impossible because Piedmont pine forests do not succeed themselves, but are succeeded by hardwood forests. Although pine seedlings come up under both pine and hardwood forests they almost never survive, whereas hardwood seedlings on the same sites survive and grow into trees. For many years there were arguments concerning the reasons for the failure of pine seedlings to survive, some foresters attributing it to drought, others to the effect of shade. Only after considerable research on the physiological processes of pine and hardwood seedlings was the difference in their behavior explained. It was found that hardwood seedlings attain maximum rates of photosynthesis at about one fourth of full sun, but pine seedlings require full sun for maximum photosynthesis. Therefore, pine seedlings growing in the shade of a forest stand do not produce sufficient carbohydrate to survive, where hardwood seedlings operating at a maximum rate of photosynthesis thrive.

Another example deals with prediction of the effect on the fish population of building flood-control dams on trout streams. The U.S. Soil Conservation Service recently proposed to build over 30 flood-control dams on the headwaters of the French Broad River in western North Carolina. The North Carolina Wildlife Resources Commission naturally was concerned about the effects of these dams on the trout population of the streams.

Some of the information required to predict the effect of the dams was available and the remainder was easily obtained. It already was known that the maximum temperature at which trout could survive in these streams was 72° F, because oxygen became limiting at higher temperatures. By measuring the temperature of the water entering and leaving existing lakes fed by trout streams it was found that the temperature was increased an average of about 13° F by impoundment. This would result in a temperature in the streams below the dams which is too high for trout and would eliminate about half the mileage of trout streams on this watershed.

In this instance there appears to be a good alternative to the proposed dams and lakes. Flood control probably can be attained just as effectively by construction of "dry dams" which impound water only during floods. Thus a combination of knowledge of fish physiology, stream ecology, and flood control engineering will solve the flood control problem without injury to the fish resources of the streams.

Lack of basic information sometimes results in programs which lead to unexpected and undesirable results. For example, some years ago a certain state garden club succeeded in having an interesting grassland area set aside as a wild flower preserve and protected from fire. It soon was covered with shrubs and young trees and lost the unique characteristics which made it worthy of protection. If the people who wished to preserve this area had consulted the local ecologists they would have learned that the existence of this grassland depended on annual burning which inhibited growth of woody species.

Unfortunately, all too often when we look for the basic information required to deal with various practical problems, it is not available because the research has not been done, or the information is not accessible in a recognizable, usable form.

WHY WE LACK SUFFICIENT BASIC INFORMATION

There are several reasons why we have so little basic information available for use in solving important problems in resource management.

One reason is the tendency of administrators and legislators to put their chief emphasis on quick solutions of pressing, practical problems. They wish immediate results. Basic research is slow, tedious, and sometimes yields negative results. Unfortunately, few people realize that the more basic the research, the wider the possible practical applications of the results. We all want applied results at once, but this is not always possible. Often we must search long and hard to find the information needed to solve a problem. Conservation activities are based on long-term considerations of public welfare. They deserve and require careful study because it usually is difficult to correct errors.

A second reason for lack of basic information is because it is easier to find people qualified to do applied research than to do basic research. It is relatively easy to train people to count and weigh and make routine measurements, but it requires much longer to train people to do original basic research. In fact there is only a limited number of people who are sufficiently original in their thinking and at the same time sufficiently patient and persistent to do good basic research. There is much talk about the need for additional fellowships to train more young scientists, but we are already training nearly all who have both the ability and the desire to do research. To get more good scientists will require indoctrinating more young people on the importance of careers in biology while they are still in high school. You people in conservation can be very helpful in doing this.

A third important reason for the lack of sufficient usable basic research is the lack of communication between workers in the field and in the laboratory. You are familiar with C. P. Snow's complaint concerning the widening gap between what he terms the two cultures, the sciences and the humanities. Sometimes it seems there is an equally wide gap between those doing applied and basic research. Unfortunately, there even is a tendency for each group to criticize the work of the other and to regard itself as superior.

WHAT CONSTITUTES GOOD RESEARCH

Perhaps it is unfortunate that a distinction is made between applied and basic research. What we really need is *effective research* on *important problems.*

Let us consider briefly what makes research effective. In this connection I wish to refer to a statement by C. H. Waddington in his book, "The Scientific Attitude."

He comments that, "One of the most far-reaching characteristics of the scientific approach to a practical problem is an insistence on deciding exactly what one is trying to do." This may seem obvious, but it often is neglected.

Perhaps we can list certain requirements for an effective research project.

1. A clear statement or definition of the problem. Too often we start work before we are quite certain what we really wish to learn. In fact it sometimes is surprisingly difficult to state clearly what we wish to do.
2. A good understanding of what is known already about the problem. This is becoming increasingly difficult with increase in vol-

ume of publication. However, unless we know what has been done we may simply waste time and money by repeating old work.

3. Finally, we should have a clear picture of what new research must be done to solve the problem.

These three steps seem commonplace, but all too often some of them are neglected. In fact if we really carried out all of these steps carefully our research nearly always would be successful.

It is true that important discoveries have been made by accident, but if we depend on serendipity to solve our problems, most of us will be disappointed most of the time. As Paul Weiss once wrote in *Science,* designing a good experiment is like aiming a rifle at a target rather than like splattering buckshot all around at random in the hope that some of it will hit something. I am afraid there is a lot of buckshot being scattered around in research today.

The definition of a research problem usually can best be made by specialists in the field. However, the other steps in developing a problem usually can be dealt with most effectively by cooperative efforts involving workers in basic and applied fields. I feel very strongly that all kinds of research benefits from frequent contact and free exchange of ideas between people working in different areas. They should not be separated geographically, intellectually, or administratively.

Unfortunately, biology has tended to become more and more specialized and compartmented. Animal and plant scientists have become more and more widely separated and each group has further tended to split into many research and teachig specialties. This is bad for progress in biology in general and it is particularly bad for progress in areas such as wildlife management and conservation where the results of research in many areas needs to be applied to the solution of pressing practical problems.

Fortunately, there are signs of improvement in some areas. For example, the increasing interest in cellular biology and biochemical genetics and use of the electron microscope to study fine structure is bringing some formerly widely separated scientists back together again. Ecological studies also tend to bring various specialists together to work on problems. Perhaps wildlife management and conservation can add momentum to this trend by encouraging the cooperation of a wide variety of scientists in solving its problems.

Those of you with applied problems must take the initiative, however, if you wish the assistance of other investigators in solving your problems. It will do no good to wait for the basic laboratory workers to come to see what you are doing or what you need to have done.

They will not come to volunteer their services. You will have to carry your problems to the ecologists, physiologists, biochemists, or anyone else who can aid you, and ask for their assistance.

THE RELATIVE IMPORTANCE OF VARIOUS KINDS OF RESEARCH

Let us now turn from the problem of efficient research to the even more important problem of what constitutes important research. Because there never is enough money or manpower to do everything we wish to do, some interesting research must be left undone. How do we choose what to support and what not to support?

In the winter issue of ***Minerva,*** Dr. Alvin Weinberg discussed this problem and suggested that we must consider not only the internal scientific merits of research projects, but also their external merits in terms of their contributions to other fields of science and to society in general. It is likely that the choice of projects will become increasingly troublesome in the next few years because problems are likely to increase more rapidly than the funds needed to investigate them. Thus competition for research money will increase and the basis for making appropriations and grants will be subjected to increasingly critical scrutiny.

At present the criteria used in choosing biological projects for support probably are inadequate because they are largely internal. That is, choices are made largely on the intrinsic scientific merits of the research without much consideration of its possible contributions to other fields of science or to society. Furthermore, a sort of "pecking order" has developed in the biological sciences in which natural resource management probably rates rather low. Groups such as biochemists, biophysicists, and biochemical geneticists seem to feel that their research is more basic and therefore more important than research in ecology, taxonomy or the physiology of whole organisms. It is proper and indeed to be expected that people should regard their work as important. However, intellectual snobbery is unfortunate because it deters bright students from fields where research is needed and makes it difficult to finance research in unfashionable areas, no matter how important it may be.

Perhaps it would be profitable to make more use of external criteria in judging the importance of research and ask which problems will contribute most to society by their solution. It doubtless would be difficult to get general agreement on the most important biological problems of today, but I believe many people will agree that the following are three of the most important problems which face the world during the next two or three decades.

1. How to control the population explosion.

2. How to manage natural resources to provide for the increasing population.
3. How to control the increasing pollution of air, soil, and water caused by human activity.

These problems are much too large for me to deal with in the available time, but I propose to discuss certain aspects of each.

THE POPULATION EXPLOSION

The rapid increase in population involves economic, sociological, and psychological problems, but it also is a biological problem which has serious implications for those concerned with the management of natural resources. It usually is attributed chiefly to the decreased death rate of infants and children resulting from improved medical care. However, this is not the entire story. Other factors must be involved, because populations of wild animals periodically exhibit increases in numbers which obviously cannot be related to improved medical care, and often are not clearly related to environmental factors.

We certainly need more research on the biological aspects of reproduction in animals. Perhaps there are cycles which are relatively independent of food supply or health. The biological aspects of the reproduction problem in humans is so overshadowed by social and religious customs in much om the world that it is difficult to foresee when any worthwhile reduction in birth rate can be expected. This is unfortunate because the beneficial effects of increased production of food and goods are being cancelled out in many countries by the rapidly increasing population. We can only hope that further biological research will provide more usable and more acceptable methods of birth control.

MANAGEMENT OF NATURAL RESOURCES TO PROVIDE FOR THE INCREASING POPULATION

As there is little prospect of controlling the population of the world in the near future we will be forced to work harder every year to provide it with food and other natural resources. The pressure for food will put an ever-increasing pressure on persons and groups such as you, who are interested in conservation of natural resources and wildlife management.

On one hand you must find enough water and land to grow food for the increasing population. On the other hand you wish to preserve some of our natural beauty in the form of recreation areas, wildlife preserves, and even wilderness areas for those who prefer packsacks and campfires to innerspring mattresses and tea rooms.

All of our thinking and planning in connection with conservation problems will be affected by the pressures resulting from increasing population.

Water Resources. The problem of water resources is particularly important in connection with food production because over most of the earth's surface, the kind and quantity of plant cover is controlled more by the water supply than by any other single factor of the environment. All over the world large areas of desert exist which would be capable of producing food if supplied with water. This does not seem very important here in the United States where we have a surplus of food, but it is of great importance in densely populated countries such as India and Pakistan.

There seem to be several possibilities for productive research leading to more effective use of water. Among these are the following:

1. Reduction of losses by evaporation. Some progress has been made in reducing water loss by evaporation from both soil and water surfaces. Application of plastic films and sprays to soil is being investigated. Spraying surfaces of reservoirs with acetyl alcohol and related substances significantly reduces evaporation. The practical possibilities in this area have not yet been fully established.
2. Decreasing water loss by transpiration. Some progress has been made in reducing water loss from transpiration by application of various sprays to plants. The older method is to apply wax coatings which chiefly reduce cuticular transpiration. More recently some interesting attempts have been made to reduce stomatal transpiration by spraying plants with chemicals which cause closure of stomata. Of course, this reduces uptake of carbon dioxide and the production of carbohydrates by the process of photosynthesis.

Perhaps the problem might be approached by searching for plants in which the stomates are open at night, permitting absorption of carbon dioxide, but are closed during the day, reducing water loss. Such plants exist, but they are mostly succulents of relatively low efficiency and limited usefulness. According to staff members of the Hawaiian Pineapple Research Institute, pineapple produces approximately as much dry matter as sugar cane, but uses only about one-eighth or one-tenth as much water. Pineapple has only limited utility, but perhaps we could find some other kinds of plants with greater usefulness which use less water than ordinary crop plants. No one has seriously searched for such plants. Most efforts have gone into increasing the drought resistance of ordinary crop plants which really have very little drought resistance to work with.

Plants for Unusual Environments. It seems possible that increased efforts should be made to find useful plants which will tolerate unusual environments such as soils high in salt or deficient in certain mineral nutrients, areas with unusual temperatures, or other factors unfavorable to plant growth. Agricultural research in the western world has concentrated on improvement of existing or traditional crops and this has almost reached its limits. Perhaps it is time to start looking for new crop plants which can be grown in unfavorable environments and when properly processed will provide food.

HOW TO CONTROL POLLUTION OF OUR ENVIRONMENT

One of the most unfortunate trends of the past two decades has been the increasing pollution of our environment by our own activities. If this continues to increase at the present rate, we may eventually make life on this planet impossible. Already it seems intolerable to some of us during rush hours on city streets when the air is filled with exhaust fumes from cars and buses.

Everyone is aware of the pollution of air, water and soil by radioactive fallout and it has been claimed that a war employing thermonuclear bombs would render the world uninhabitable. Fortunately, the danger of such a catastrophe seems to have diminished somewhat during the past year or two. However, the amount of pollution from industrial wastes and automobile exhaust fumes continues to increase. I regard this kind of pollution as a more serious problem than pollution by radioactive fallout.

The pollution caused by dumping of industrial wastes and raw sewage into rivers seems to be manageable, although it remains a major problem in some areas. Air pollution by smoke also has been decreased materially in many cities, proving that remedies can be found for some pollution problems. However, air pollution by smog, formed chiefly from auto exhaust fumes, is increasing all over the world. Dr. Frits Went, an authority on smog, states that smog injury now can be observed on vegetation in and around all the major cities of the western world.

In California smog damage now occurs on crops at a considerable distance from cities and it is likely to spread farther and farther under certain atomospheric conditions. New examples of injury by sulfur dioxide and fluorides to vegetation in the neighborhood of smelters, steel plants, and fertilizer factories continue to be reported. Vegetation along our highways becomes contaminated with lead from exhaust fumes and deformed by herbicides used to maintain power lines. I will not go into the highly controversial area of the use of insecticides, but one must grant that some real dangers exist in this area.

An interesting, but little-discussed problem is the increase in carbon dioxide content of the air resulting chiefly from the tremendous amount of fuel burned by industry. It now appears that the sea is not as good a regulator of carbon dioxide as was once supposed and the carbon dioxide produced by burning fuel is accumulating in the atmosphere instead of going into solution. Some scientists believe that a significant increase in carbon dioxide concentration of the earth's atmosphere will result in a measurable increase in the earth's temperature which might have serious effects on climate. Perhaps increasing use of nuclear energy will decrease the production of carbon dioxide and avert this danger.

Taken together, these various forms of pollution constitute an inincreasing menace to plant and animal life, including humans. They are a much greater menace to health than cigarette smoking because they affect more people more continuously. Obviously, more basic research on the biological effects of these various polluting substances is needed.

AESTHETIC AND RECREATIONAL VALUES

Thus far I have dealt with practical problems of research, but I now wish to consider briefly the less tangible but equally important aesthetic and recreational values of conservation and wildlife management programs. Most of our interest in this field arises from our love of nature. We believe the aesthetic values of rivers, lakes and forests and the wildlife in them are as important to the welfare of modern man as his apartment houses, skyscrapers, and factories.

In the United States there will be no serious pressure for increased food production for many years to come, but there already is severe pressure on our reecreational areas. Short-sighted and selfish interests convert beaches into amusement parks and forests into real estate developments. Superhighways are run through natural areas and hydroelectric plants drown beautiful valleys. This kind of pressure is unfortunate, but it is the inevitable result of our expanding population.

Organizations such as those meeting here must endeavor to prevent long-term conservation and recreation needs from being overlooked or disregarded by the pressure of short-term economic considerations. Otherwise, we may gain the moon, but lose the earth.

SUMMARY

1. Development of effective management programs for our biological resources requires a thorough understanding of the basic biochem-

ical and physiological processes which control the growth and behavior of plants and animals. We cannot grow trees efficiently unless we understand how trees grow and we cannot manage fish and animals until we understand their biology and how they interact with their environment.

2. We need much more biological research to provide the information required to develop sound management programs. To obtain this information we must:

   a. Exercise greater selectivity and concentrate more effort on research which seems likely to contribute most toward solution of particularly pressing problems.

   b. Increase the effectiveness of our research by better definition of our problems and by obtaining better cooperation between investigators in applied and basic areas to bring a wider variety of information and skills to work on conservation and management problems.

3. We must find the money to support the needed research. To do this we must carry on educational campaigns to keep the public and our legislators informed concerning the importance of these problems and what needs to be done to solve them.

4. All future planning and programs in the fields of conservation and wildlife management must take into account the rapidly increasing population. This will intensify the competition for land and water at the same time that it increases the need for better protection of our natural resources.

LAND, PEOPLE, WATER: PROBLEMS AND SOLUTIONS

ROBERT E. DILS[1]
Professor, Colorado State University, Fort Collins

I accepted your vice president's invitation to speak on this subject with one large question in my mind. I imagine that he extended the invitation with the same reservation in his! There are few, if any, subjects of more import to the United States and to the world than our future treatment of our land and water resources. For many years it seemed completely foolish to worry about either. The United States had plenty of land—good land. By and large, we had plenty of water too. Oh, there were problems—but the most severe of them existed where very few people were trying to exist—so why worry? This comfortable complacency was unshakable for a while, but the conditions which allowed it did not remain static. We had to wake up—and we did. Not, in many cases, as rapidly as the far-sighted might have wished—but at least we were stirring. Where it once had seemed foolish to discuss soil and water conservation, it now became downright fashionable! It became the theme of countless meetings and discussion groups. Pamphlets were issued, films made, and a small library of books published. The professional societies to which you belong, your wife's garden club, and probably your sons' and daughters' scout troops have examined the subject exhaustively (and perhaps even exhaustingly). So the question in your vice president's mind, in mine—and in yours—is undoubtedly this: Is there anything further to be said on the subject without simply parroting what has been said? I think there is.

You, and each of the other 190 million United States citizens like you, now have twelve acres of land for your support and sustenance. In 1920, you had 22 acres. By 2000 A.D. this theoretical land-holding of yours will shrink to about 7½ acres (Clawson, 1963).

An average annual precipitation of 30 inches and our ground water reserve is available to provide the water you need. The crux of our land, people and water problems lies in the fact that these land and water resources are essentially fixed while our "people resource" is continually increasing.

LAND

Our land problems are many, varied, and often extremely complex—from economic, social and legal aspects, as well as from the physical standpoint. Our major demands are for cropland, grazing, forestry,

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recreation, urban and industrial development, and transportation. According to the U. S. Bureau of the Census (1962), in the 48 continental states, 24 percent of the total land area is in cropland, 33 percent is in grassland, pasture and range, and 34 percent is in woodland. Special and miscellaneous uses account for the remaining 9 percent.

Croplands today present some of our most serious problems. Marion Clawson (1963) concludes that the basic agricultural problems of the nation are, paradoxically, poverty and surpluses. He notes that in 1959 we had some 750,000 part-retirement or commercial farms whose owners or operators received a net income of less than $2400 per year. This is total income—it includes the value of their farm-produced food and housing as well as wages they had been forced to seek in off-farm work. The low standard of living of the people involved, and the national loss from these low-income farms is obvious.

We must then deal with the problem of farm poverty and at the same time face the problem of agricultural surpluses. Agricultural research, new technology and automation have made our farmer the most efficient food producer in the world. Unfortunately, economic social and political changes have not kept pace with physical advancements. Despite continued and varied efforts to find solutions, surpluses mount while the farmer's economic status worsens.

Various estimates indicate that, at least in the immediate future, we will be able to provide all the food we require for our rapidly increasing population on even less cropland than we now use. This is not quite the good news it would at first appear to be. It will intensify both sides of our cropland problem. Small marginal farms will be even less needed than they are now—and surpluses may be even greater.

While our forest lands are providing for our present needs in timber resources, the future does not look quite so promising as it does in the case of agricultural products. Despite the fact that figures show a decline in per capita consumption of lumber, due to high costs and more suitable substitutes, the potential total market for lumber is expected to increase 30 percent in the next 3 decades (Clawson, 1963). The consumption of both pulpwood and plywood has skyrocketed. This trend is expected to continue until, by 2000, we may need as much as 4 times our present requirements. Fifty to 100 years are required to grow trees of sufficient size to produce sawlogs and plywood. Thus, most of the land which would supply these products by 1980 or 1990 should already be well stocked with vigorous forest stands.

If it were possible to manage our forest lands just to produce the maximum amount of this needed timber, our problems would be simplified. But we cannot limit ourselves to this one objective. One-half to three-fourths of our annual supply of precipitation falls on the forest. We can't just manage the forest to produce lumber—we must also consider water yield and quality. A second variable in this equation is the current and continuing boom in the demand for recreational land. Since the vacationist dreams of trout, tents and towering trees his demands too will involve primarily our forests. We cannot fulfill his dreams with figures announcing only a maximum production of pulpwood. Unless we find effective ways to balance our forest equation, shortages are bound to be felt.

Six hundred thirty million acres of our land is now in grassland, pasture and range. Over half of this area is in the West—and much of it is in federal ownership. There will be use-shifts here. Reclamation and water development will upgrade some of it to cropland. At the other end of the scale, conversion of marginal or low-productivity cropland and non-commercial forest to grazing use will probably bring about a modest increase in the total acreage included in this classification. However, we're going to need a great deal more of the meat than this grass and rangeland produces. Some of this increase will come from feed and pasturage produced on croplands, but we must also intensify our range management. Large acreages are now in need of brush control. Other areas now in low quality cover should be converted to better forage types. We must improve our techniques of reseeding and range fertilization. We must also focus attention on the application of soil and water-holding measures. Rangelands are often sediment-producing and we must protect any water supply which originates in or flows through them.

The special uses category of our land resource is the smallest in area—9% of the total—but it is here that the most dramatic changes can be expected. We can't do much about 50 million of these 170 million special-use acres. They are wastelands and will remain in that category. The remainder of this acreage must fulfill a multiplicity of needs. Airports, military reservations, rural parks, wildlife refuges, institutions, and manufacturing plants require increasingly large blocks of land. Not only do expanding cities require more of everything we now produce, they demand—and take—land for this expansion.

Hockensmith (1963) estimates that approximately 1 million acres of land are removed from other uses each year for this urban sprawl and for the highways and airports needed to service it. As cities grow, the needs for special recreation areas grow with them. Another million-plus acres of land are being withdrawn each year from forest, grazing and croplands for recreation-related developments. If these two trends continue at only their present rates, some 38 million acres would be diverted from their current usage by 1975 (Hockensmith, 1963).

WATER

Nature has endowed the United States with an average annual precipitation of 30 inches—a little more than the estimated world average of 26 inches. Of this total, approximately 22 inches is consumed in evaporation and transpiration. Eight inches finds its way to our streams as runoff. If these averages were evenly distributed throughout the United States we would have an adequate water supply for today and for the foreseeable future. Unfortunately, this is not the case. We have some areas with surpluses and flood problems and other areas with serious shortages. In still other areas we so abuse the water resource available to us that we literally destroy it from a quality standpoint.

A consideration of our water problems requires a look at the pattern of its use. As a nation, 46 percent of our water is used by industry, another 46 percent is used in irrigation and only 8 percent is used for municipal and domestic purposes. Geographical comparisons are also necessary for an appreciation of the different problems involved. In the East, industry is the major consumer. In the West, irrigation claims over 85 percent of the total. Gross use data are, however, misleading in some respects. In the West, water is not only used—but "used up." Only a fraction of irrigation water is available for re-use downstream, and much of the original amount is lost to evaporation in storage or in transit.

Conversely, much of the water used by industry is for cooling and processing. Alterations in its quality may require expensive treatment, but a large quantity of it may be returned to the streams for possible re-use.

Climate too plays a very significant role in our problems with water. In the relatively well-watered East, droughts do occur, but they are likely to be localized. Floods are a greater threat—especially when increased occupancy of flood plains and periodic excesses of rain coincide.

With the exception of the Pacific Northwest, the western states are not so well blessed with rainfall. Widespread droughts are fairly common and water shortages numerous. The U. S. Senate Select Committee (1960) anticipates that serious shortages are likely in 8 of 22 major water basins throughout the United States by 1980 unless bold water development projects are undertaken. Many of these critical areas would be in the western states where climate plays a further role. Much of our precipitation occurs as snow and accumulates over winter in the mountain watersheds as frozen assets. In order to use this reserve as it melts and runs off in the spring and early summer, it is necessary to construct large and expensive reservoirs.

Due to climate too, the loss of stored water to evaporation is of major significance. Evaporation losses from water surfaces in the arid West have been estimated to be about 25 million acre feet of water annually. An additional 25 million acre feet of water is lost by transpiration through water-loving vegetation growing along the streams and lakes.

The water problems of the East will probably continue to be centered around local shortages, general flood control, improvement in water quality and the development of improved methods of treating, diluting and disposing of industrial and municipal waste.

In the West, we must face the fact that there will not be major increases in the amount of water available for our major use—irrigation. In terms of population the West is out-growing the East. Industry and growing municipalities can pay more for their water and will also receive the highest priority for increasing use. Therefore, concentration in the West must be on reducing evaporation and deep-seepage losses through improved methods of transporting and applying irrigation water. Second, we must attempt to reduce salinity and to cut down losses to phreatophytic vegetation if irrigation agriculture is to enjoy much expansion.

Throughout the nation, land management activities on the watershed must be intensified so as to increase or maintain water yields, effect more favorable timing in streamflow, improve or protect water quality, and to improve or maintain productivity of the soil. Alteration in the water laws of some of our states to recognize recreation as a beneficial water use will be made by popular demand.

The atmosphere, the oceans, and in certain areas, ground water reserves, provide vast water reservoirs which we will tap in the next few decades.

PEOPLE

The real key to all our land and water problems is, of course, people. During the course of this three-day conference, our population should have increased by some 25,000. Many estimates indicate that the United States will harbor at least 300 million people by a brief 36 years from now. Some projections indicate a population of nearly 425 million by that date. In any event, the demand on our more or less fixed land and water resource to provide food, fiber, water and shelter for the future is staggering.

Population figures of the United States alone are inadequate to view realistically the pressures of the future. Statistics in the world arena are even more startling. Most of the nations of the world are not so well blessed with land and water resources as are we. Undoubtedly we will be expected to continue and to increase our support to them.

Simply counting the people who are likely to be around in 2000 is not enough for the projections we must make. We must also consider the fact that each of these individuals will increase his consumption of our natural resources. For example, our per capita use of water has more than doubled in the last fifty years. A high percentage of our new housing has been in single units which require more lumber and more land than multiple units which are built up instead of out. How long these trends continue and how can we best solve the problems which they create?

Today we lack refinements in our economic tools and analyses to permit a realistic determination of many resource values and uses. The use of water for recreational and aesthetic purposes has very definite social values yet our methods of assessing them are woefully inadequate.

Resource laws are the social vehicles for adjusting resource uses equitably. Many of our present statutes are still geared to the horse and buggy era while we are attempting to develop and manage our resources in a space age. Many of our state water laws fail to recognize the intimate relationships which exist between surface and ground water. What legal disposition will be made of additional water which may be made available in the future by vegetation removal, evaporation suppression or rainmaking?

I suspect, too, that Secretary Udall's handball partner would welcome any realistic suggestions on how to reduce our agricultural surpluses and what to do with the 750,000 marginal or submarginal farm units.

The economic, social, political and legal problems involved in our present future use of land and water are immense. Usually they far eclipse their physical and biological counterparts. These problems are neither theoretical nor rhetorical—they are dynamic and urgent.

TOWARD RATIONAL SOLUTIONS

Since magic is not one of the resources available to us for problem-solving, I must now parrot something I know you have heard before. Solutions to our resource problems will be found through education, research and cooperation. This phrase may sound a little like the polly-annaish motto of a smiling service club, but for us it must contain the hard core of truth and realism.

Educational institutions have been turning out foresters, range managers, wildlife specialists, agronomists, engineers and resource scientists for many years. These programs enjoy public and professional acceptance and we will continue to need this type of specialist. However, as new technology has emerged in each of these fields, their respective programs have usually become more narrowly oriented toward the specialty—often at the expense of the basic physical and social sciences and of the humanities. It has been somewhat ruefully said that "a specialist is one who knows more and more about less and less." To meet the challenge of our complex problem in the future, a new type of educational program must be developed. We must learn how to train "generalized specialists" or "specialized generalists"—the turn of the name doesn't matter, but what it implies does. These men must, literally, know more and more about more and more!

Training such a man will not be simple. In all likelihood, the student who wants to pursue a program, preferably at the graduate level, in natural resources will have to be a better-than-average student and probably will find that it will take him longer to complete his degree. Possibly, such a student would first be required to have intensive professional training in one single natural resource field. A graduate program would then build upon this base, providing additional training in his first field and specialized training in several other resource fields. Assume that a graduate in civil engineering wishes to pursue an advanced program in natural resources with particular emphasis upon water resources. In addition to specialized courses in civil engineering, particularly hydrology, he would be expected to complete courses in soil physics, watershed management, ecology, geomorphology, atmospheric science, resource or water economics and water law. If his interests were primarily in a career in water resources administration, he would take more coursework in the social sciences. If research—more emphasis would be placed on becoming adept in using the tools of research such as statistics, data processing and higher mathematics.

Educational institutions are responding to this need by establishing resources institutes or centers for both interdisciplinary study and research.

Many of the federal agencies engaged in resources research, development and management are now authorized (Public Law 85-507) to send up to one percent of their employees to educational institutions each year for specialized training. In view of the increasing complexity of our problems and of the knowledge needed to solve them, this law should be amended to increase this percentage. Provisions should also be made to offer the same opportunity to qualified state employees.

Resources research programs of a number of the federal agencies have made remarkable progress in the past decade. New research facilities of the Public Health Service, Agricultural Research Service, and the Forest Service are appearing throughout the nation. Usually such laboratories are constructed on or near university campuses, thus promoting greater cooperation between the educational institutions and the research agencies. Continued and expanded cooperation is essential if we are to produce both the researchers and the research we need.

Recently Dr. Abelson writing in *Science* (Troan, 1964), took the nation's educational institutions to task for over-emphasizing research. While there is some justification for Dr. Abelson's criticisms, there are also several points in defense of the university which should be noted. The emphasis of the university has been and is undergoing marked changes. Even at relatively small institutions such as my own, over 10 percent of the student body are graduate students. At some institutions, from 40 to 50 percent of the total enrollment is in the graduate school. Percentagewise, graduates are increasing more rapidly than undergraduates. And graduate study is necessarily tied to research. Much of Dr. Abelson's criticism was directed toward development of so-called "academic stars" whose time is spent almost entirely in research and who seldom come into contact with undergraduate students.

At some universities it is no doubt true that the "academic stars" seldom teach undergraduate classes. Often, however, they do teach graduate courses and conduct seminars and spend a large amount of time with graduate students. Frequently, too, they must spend more time soliciting funds for research to support a growing program then they do in research per se.

Unfortunately, we have yet to find a suitable, acceptable measure for assessing excellence in teaching itself. The university needs to find such a yardstick—one which is not just a popularity contest.

The Federal Government has played a very significant role in the development of the super professor, the distinguished professor or the academic star. By virtue of his past successes in research and in soliciting research funds, he becomes known as a self-starter. Consequently, he is much in demand in the academic market place, for when he moves he often may be so well established with the funding agencies that he can either take some of his research with him or be virtually assured of funds in his new position. Within a relatively short period of time he often can build up a research program which will not only support his graduate students and their research, but will also cover a major portion of his staff salaries and expenses.

While such practices tend to develop centers of excellence at some institutions, they have a very eroding effect on others, particularly on smaller universities which cannot compete economically for such people. Not only do they lose their stars, but the blossoming program at the bigger or better research-financed institution often pulls away their better young faculty members and their research and teaching potential.

Through its fund-granting procedures the Federal Government is also playing a major role in reshaping university research, and indirectly, university teaching. In part by virtue of their many academic stars and in part due to their experts in "grantsmanship," a number of centers of excellence have been developed.

Paul Friggens (1964), writing in the January 1964 issue of *Reader's Digest,* notes that federally supported research at the University of California is now almost 200 million dollars; the University of Wisconsin, 28 million; and the University of Illinois, 25 million. At M.I.T. 70 to 80 percent of its total budget comes from Washington; at Princeton, 50 percent; and at Harvard, 25 percent. From such centers of excellence we have and will continue to receive significant research results and many well-trained scientists. However, if we are to meet the total educational and research job ahead, additional resources will need to be directed to the improvement of many other institutions. Perhaps some of the National Science Foundation research funds should be made available to university administrators outside the centers of excellence on a non-project basis to permit them to shore up weaknesses in their program.

If the Federal Government continues to provide a major source of funds for university research, perhaps some graduate programs should include training in proposal writing or grantsmanship. Unquestionably the experienced researcher and those who have the advice and assistance of experts in writing up possible research projects submit proposals far superior to those of the novice. We lose the high research potential of the talented beginner when he lacks experience and the knowledge of what reviewers look for in proposals.

This year, the new McIntire-Stennis Law is providing new funds to universities for forestry research. Similarly, if the proposed Water Resources Research Bill and the Land and Water Conservation Fund Bill are passed and implemented, additional funds will be available for initiating research. Hopefully, these federal funds will serve as a catalyst to direct more state and private money to the land and water research effort.

A third facet of the task of finding solutions to our resource problems is cooperation. Solutions to the difficulties cited above and to many similar ones are going to be increasingly complex and hard to find. They will require a simultaneous attack on many fronts.

In the natural resources field a wide variety of agencies and disciplines are involved. In the area of water resources alone, at least 25 federal agencies have some responsibility. Progress in cooperation among these agencies is being effected—through inter-agency committees, and the activities of the National Academy of Science-National Research Council and the Federal Council on Science and Technology. We need even closer cooperation and coordination.

Similarly, there has been encouraging progress in cooperation between public agencies and educational institutions particularly since World War II. Typical of such cooperation is the location of federal research laboratories on or near university campuses, the increasing number of public agency-university cooperative research units such as we now have in fisheries, wildlife, recreation and watershed management, and the federal employees training act authorizing the return of selected employees to the university for specialized training. Such cooperation should be continued and expanded.

An excellent example of progress through cooperation is provided in Colorado. For years ranchers in western Colorado who utilized the range resources of the national forests were joined in battle with the Forest Service over grazing allotments. Recent cooperation by the ranchers and the foresters has shown the way to increased grazing and improved federal range.

There are countless problems which will still be researched by the more narrowly trained specialists. At the same time there is a big need for our so-called "specialized generalist" and for team research to seek solutions to many of the more complex problems. Team research will require a new kind of cooperative effort.

As specialists in the various aspects of natural resources we cannot ignore the challenge facing us, and I feel that we are ready to meet it and to accept its responsibilities.

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MR. GAMBERT [Wisconsin State College]: I would like to ask the speaker along what major factors, other than tradition, he bases his assumption that generalist training should come at the graduate as opposed to the undergraduate level?

DR. DILS: We have had a number of institutions which have attempted to train generalists at the undergraduate level and, although it may provide an excellent degree program in the arts and sciences, for the most part, these people have been unemployable and, that reason, I think (among others) that I would prefer to see such a broadened program at the graduate level. It is very difficult for an agency such as the Forest Service, for example, to hire someone who has a degree in conservation. He must first be qualified for civil service as a forester or as a soil scientist or range conservationist.

MR. ONTHANK [Oregon]: I think Dr. Dils has given us an excellent picture of what can be done in the years immediately ahead and what is already being done.

I just happened to come from a conference on population problems and I wonder —apropos to the fact that people as well as other factors are listed in his topic— whether he would have any comment on how long the major measures described can keep ahead of the growth in population?

DR. DILS: I don't think I can give you an answer on that. We have a lot of people working on it but we do not have any answers.

MR. GALPERT: Again, I don't want to belabor this point, but it seems to me that Professor Dils paraphrased what I tried to rule out by saying that tradition was the only answer. What I was trying to find was some other and more justifiable answer.

DR. DILS: I would have to give more thought to this to come up with some deep and probing answer, but, fist, I will say we have to have a tradition. We, as specialists, can alter the regulations governing employment standards to permit agencies to employ people with a generalized training in conservation, such as a Bachelor's Degree. However, at the root of your question, we must have selected individuals, but, in the long run, it doesn't make too much difference whether they get their specific training early and then broaden out or, on the other hand, take their broadened training first and then becomes adept at specific directions. I think this is going to depend upon the individual rather than the program.

PROGRESS IN RESEARCH ON NATIVE VEGETATION FOR RESOURCE MANAGEMENT

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Vegetation of rich variety and abundance in our vast forests and rangelands has been a major factor in the development of this great nation. It has provided timber for industry and homes; forage for our flocks of sheep and herds of cattle; food and cover for wildlife; and an aesthetically pleasing cover for the landscape. Vegetation and its residues have also performed a dominant function in safeguarding streamflow for domestic, urban, and industrial use.

During agricultural and industrial development of our country, we did not use wisely this vast natural heritage of ours. Abuses resulted from many factors, not the least of which was ignorance regarding vegetation and its requirements.

Of our original heritage of two billion acres of forest and rangeland we retain about one and one-quarter billion acres. Thus our acreage of forest and rangelands has shrunk, and it is continuing to shrink. The native vegetation on these lands is in various stages of depletion. Consequently, production from this acreage—particularly forage production—has declined. At the same time, demands for varied kinds of goods and services have multiplied.

To provide as much as possible of these goods and services, we face a major challenge in.rehabilitation and in skillful management of forests and rangelands. This calls for detailed expert knowledge about individual species of plants, plant communities, their relation to environment, and their relation to use.

During the last half-century we have made substantial progress, learning from our mistakes, from experience, and from research. The additions to our knowledge about vegetation have been so numerous and vast that no one person can realistically select the most important. Therefore I shall use as examples certain outstanding contributions from the sciences of plant physiology, ecology, and genetics. These contributions are of major significance, not for knowledge alone, but as a basis for management of vegetation or land.

PLANT PHYSIOLOGY

Progress of research in plant physiology has been of basic importance in determining how to reproduce, grow, maintain, or control native vegetation. I shall mention just three examples of progress—

one dealing with the effects of defoliation, and the other two with plant-water relations.

Defoliation, either partial or entire, of plants on forest and rangelands is commonplace. It is the inescapable result of grazing by livestock, grazing or browsing by big game, feeding by defoliating insects, attacks by certain plant diseases, feeding by rabbits, and use of some methods for plant control. All kinds of defoliation affect plant growth.

Physiological studies of the plant, whether it be a grass, forb, shrub, or tree, show that defoliation checks growth primarily by reducing the amount of carbohydrates available for growth (Kramer and Kozlowski 1960, p. 526). The effects of defoliation are especially severe at times during the annual growth period when reserves of carbohydrates are low (McCarty and Price 1942), and when opportunities for regrowth are small (Blaisdell and Pechanec 1949). Most plants are capable of replacing tissue and recovering if defoliation is not too heavy, if reserve food materials are available, and if temperature and soil moisture conditions are favorable for regrowth. Recent research has shown many minor variations in these principles.

Progress in this type of physiological research is basic to developing efficient management systems and rates of grazing for livestock on rangelands, and for developing standards of utilization for desirable species on big game ranges. Results of recent research are essential to evaluating or predicting effects of epidemics of defoliating insects. They are helpful in devising better methods for controlling undesirable or less desirable perennial plant species.

An understanding of plant-water relations should guide many aspects of vegetation management. One extremely important application lies in the possible manipulation of vegetation to increase water yield—a subject of vital importance to us in the West. Plants use large amounts of water; species vary widely in their efficiency of water use. A few long-term research projects have clearly shown that removal of some species of riparian vegetation and changes in forest cover can increase streamflow appreciably (Johnson and Meginnis 1960). There is, however, much to be learned about where such benefits can be obtained and whether they are great enough to justify such treatments.

Knowledge of root-shoot ratio and its effect on balance between rate of water absorption and water loss by transpiration has led to increased success in planting trees and browse (Kramer and Kozlowski 1960, p. 296). Loss of roots during the lifting of tree seedlings from nursery beds is an important cause of mortality in plantations. Desiccation results when water is transpired more rapidly than it is absorbed by the reduced root system. Reduction of transpirational losses through such practices as clipping off part of the top, clipping needles of conifers, or coating of the top with waterproof substances has increased survival and improved growth of planted seedlings (Allen 1955; Miller *et al.* 1950).

PLANT ECOLOGY

It is in ecological research, which has great practical importance to resource management, that the greatest progress has been made. Advances have been made in both autecology (the interrelations of the individual plant and its environment) and synecology (the structure, development, and relations of plant communities to their environment).

Periodic establishment of new young plants of commercial tree species, browse plants, or desirable grasses and forbs is essential to maintenance of high productivity of forests and rangelands. Since most of the plant species with which we are concerned in the West reproduce by seed, the rapidity of establishment of new plants depends in part on the frequency and abundance of seed crops, and in part on the following year or years being favorable for germination and survival of the seedlings.

Under the arid conditions usual in the West, years of good seed production may be relatively infrequent. For example, good cone crops of ponderosa pine in Arizona were found to occur once in 3 or 4 years (Pearson 1950), and once in 5 years for white pine in northern Idaho (Haig *et al.* 1941). Good seed crops of Indian ricegrass were found to occur once in 6 years in western Utah (Hutchings and Stewart 1953), and of bluebunch wheatgrass, once in 5 years in eastern Idaho (Blaisdell 1958).

In general, then, good seed years are infrequent. And the association of good seed years with subsequent climatic conditions favorable to germination and survival is even less frequent. Only once in 38 years was there abundant and widespread reproduction of ponderosa pine in Arizona (Pearson 1950). In only about one year out of 10 were the seedlings of perennial grasses abundant in eastern Idaho (Blaisdell 1958).

With knowledge of this kind the timber manager can decide whether to rely on natural regeneration following timber harvest, or to plant seedlings for prompt establishment of a new crop of trees. The range manager can better develop prescriptions for grazing management that will permit maintenance or range improvement. And the wildlife manager can predict with some certainty the length of time necessary for improvement of critical big game range that is badly depleted.

The concept of climax plant associations as developed for the forest vegetation of northern Idaho by Daubenmire in 1952 is essential in relating existing plant communities to a common pattern of development. Such a concept is indispensable to the forester "since silvicultural operations are fundamentally based on accelerating, retarding, or arresting the natural succession of vegetation" (Puri 1950). The role of vegetational succession is particularly significant for many of our most important western conifers such as white pine, Douglas-fir, and ponderosa pine in portions of its range, which owe their dominance to past wildfire.

These concepts of plant succession have had major application in range management, where the condition of a range is based on stage of plant succession under grazing use, and effectiveness of management on the trend in succession (Dyksterhuis 1949; Parker 1954; Sampson 1919). This knowledge about plant succession is beginning to be applied in management of big game ranges.

Of major significance has been progress in understanding the relation of kind and amount of plant cover to soil stability and to accelerated erosion. Major disturbance of vegetation, whether by overgrazing, burning, use of destructive logging methods, trampling by man in campgrounds, or other factors, is likely to result in erosion and site deterioration. Knowledge of relations of successional status to erosion has greatly helped in identifying hazard, but more recent research indicates that further work must be done (Ellison 1960). Knowledge of minimum ground cover requirements to prevent overland flow and erosion (Packer 1951) has aided materially in identifying hazard.

Another important advance in ecology has been our comparatively recent increase in understanding of the role of wildfire as a fundamental force in plant succession. Until recent levels of fire protection were achieved, wildfire had always been an important factor in the terrestrial environment of many plant communities (Daubenmire 1947, p. 329). Many of our best forest types for commercial timber production (LeBarron 1947) and some of the better big game habitat owe their existence to past catastrophic fires. As a result of the reduction in or exclusion of fire, many of these plant communities have been undergoing a subtle but pervasive major change.

For many reasons, we can no longer tolerate the immediate disastrous effects of wildfire. We do, however, need to know more about what changes will ultimately result from complete protection. Where they are not in the best interests of the use and enjoyment of vegetation, we must find ways to use fire as a tool, or develop alternatives to achieve the same ends. This must have been what Leopold and his associates had in mind in their comments on restoration of the primitive forest in the national parks (Leopold *et al.* 1963).

PLANT INTRODUCTION, SELECTION AND GENETICS

Dramatic progress in improvement of the type of vegetation has come about, or can be expected to soon, from research involving introduction of new species; from selection from natural strains for improved usefulness, productivity, or resistance to pests; and from genetics and breeding.

Numerous attempts have been made to introduce exotic forest trees into the United States, but they have met with little success. By contrast, little has been done to introduce or propagate new species of browse. Some introduced grasses, on the other hand, have been notably successful in rather widespread use; these include crested wheatgrass, the lovegrasses, and other grasses suitable for seeding deteriorated western ranges.

Of far more widespread significance, especially for the future, are advances being made through racial selection and breeding. Through this process, strains of western white pine are being developed that show strong resistance to blister rust (Bingham 1962), strains of slash pine that are expected to produce twice the present average yield of oleoresin (Dorman 1961), and hybrid pines resistant to the reproduction weevil (Smith 1960). Racial selection and breeding have also developed strains of native western grasses such as Bromar mountain bromegrass and Primar slender wheatgrass (Hafenrichter *et al.* 1949). These grasses are superior in disease resistance, yield, or other characteristics. Little has been done yet to develop or improve native shrubs that might be useful for big game browse.

EVALUATION OF PROGRESS

These few examples only suggest the monumental progress in research on native vegetation. I could also have measured our increase in knowledge in terms of the number of new textbooks on the various plant sciences that have appeared in the last 30 to 50 years, embodying the progressively mounting fund of knowledge. I could have cited the increasing specializations in some branches of plant science, such as plant physiology; or development of wholly new fields of applied plant science, such as range management, which originated in the United States and has been exported to the world now as a completely new concept and a new term in many foreign languages.

All of these expressions are significant indexes of how far we have come, but are not very meaningful without a base of reference—how much do we *need* to know?

From the standpoint of the scientist, whose main motivation may be the challenge of an unsolved problem, the search for knowledge is virtually endless. Each new solution is likely to disclose several additional unsolved and intriguing problems.

From the standpoint of the manager of forests, ranges, wildlife habitat, watersheds, and outdoor recreational areas, we still cannot estimate how much we will need to know in the future. But we can say with some assurance how much we *now* need to know to cope with immediate problems.

We have reasonably good knowledge of how to establish and grow the major commercial tree species; how to graze rangelands; or, by seeding or other means, how to maintain or improve the vegetation; and how to avoid accelerated erosion. We know much less about successfully manipulating vegetation on forest and rangelands to influence water yield or stream regimen. Even though we have some indications regarding the type of plant cover needed, we know little about how to get it and how to perpetuate it in the face of natural succession. We are scarcely in any better position to manage vegetation for wildlife habitat, especially for small game and upland birds. And we have only fragmentary knowledge about managing the habitats of the nongame species, such as the Kirtland's warbler (Radtke and Byelich 1963).

In management for outdoor recreation, a host of wholly new problems in vegetation management faces us. Man is as bad as, if not worse than, a band of sheep or a herd of cattle when he tramples the site and vegetation of campgrounds or picnic areas. These small areas involve different kinds of impacts than those heretofore studied and many plant species that have little significance for other uses. Other problems, such as restoration or maintenance of beauty, of good huckleberrying, or those associated with the concept of biotic management for national parks (Leopold *et al.* 1963) involve challenging new concepts.

In this evaluation I may unintentionally have given the impression that we do not know much. We know a great deal—perhaps more than has yet been applied. Even so, we need to know considerably more to achieve prescriptive management. We cannot yet analyze the features of the complex landscape and with any certainty prescribe what needs to be done to achieve and maintain any objective of management for specific use, such as production of timber or range forage. We are even less able to prescribe what to do and how to do it to achieve the blending of two or more uses required for multiple use management.

MAN IS CHANGING ENVIRONMENT

Man has already caused major changes in plant environment and the total biotic complex. I have mentioned the ravaging of forests, the overgrazing of rangelands, and the very serious erosion and loss of soil. These are the major and most far-flung effects Man has caused until the present. I have also mentioned the elimination of periodic wildfire and the changes that ensued. I could also have mentioned the accidental introduction of such new plants as cheatgrass, or new pests such as the gypsy moth, blister rust, and chestnut blight. All of these have brought new and major problems in vegetation management.

However, other problems on the horizon may be far more significant in their general impact on environment.

Man already may be responsible in part for a warming trend in the world's mean annual temperature. This had risen 1° F. from 1885 to 1945 (Mitchell 1961). In most of the United States, summers are now 1° F. warmer and winters are 2 to 4° F. warmer. This rise in temperature has been attributed to the fact that the carbon dioxide content of the atmosphere has risen 13 percent during the last hundred years; it is said that the combustion of coal and oil are largely responsible (Plass 1959; Junge 1960). It is estimated that in another 50 years, 47 billion tons of carbon dioxide will be added annually. These rises in temperature, from whatever cause, can have substantial effects on tree health and vigor (Hepting 1963).

Other gases being discharged into the air are beginning to have deleterious effects on forest vegetation (Berry and Hepting; Parmeter *et al.* 1962). Substantial masses of air pollutants are being created; these are destined to increase materially unless we learn to cope with the sources.

The use of large amounts of chemicals for fertilizing, for plant control, or for disease or insect control can have effects on vegetation that we do not yet understand.

The possibility of introducing new diseases or new insects is ever with us. The introduction of new plants, either purposefully or accidentally, will also continue.

Weather modification—much discussed during the last 15 years—cannot yet be applied on any extensive basis. Many possibilities that stimulate the imagination are being considered (Petterssen 1964). If some should ever be perfected, they might have more far-reaching effects on vegetation than any of the forces so far mentioned. What they will be and how they will operate are not clear, but certainly these effects will accrue not only at the location where the change is being sought but in other locations as well.

Since vegetation is strongly influenced by its environment, these factors I have mentioned and their effects on vegetation must be understood if we are to use them wisely, avoid damage, or develop management systems to control them.

LEAD TIME IS NEEDED

In this modern age, space exploration with all of its numerous spectacular features, electronics, and atomic energy have dominated and to some extent overwhelmed our understanding of the workings of scientific research. We have come to believe that results can be achieved overnight—particularly if large amounts of money are spent. But these impressions are misleading in many ways, especially as they relate to research on vegetation of forests and rangelands.

Even though application of results is immediate—and we know that there are substantial lags—the intended benefits from many aspects of vegetation management may not accrue for many years. Appreciable benefits from improved grazing management frequently take from 3 to 10 years to develop—even longer if the range has deteriorated badly. The same is true of big game winter range where most of the desirable shrubs have been killed out or weakened. Thirty years or more may be required from the time of discovery of superior germ plasm in a forest tree until adequate seed supplies of that superior tree have been produced and enough seedlings are available for planting in the forest. A plantation of white pine, planted today, will not supply much toward our wood needs until the year 2024 or later.

Many types of vegetation research require 5, 10, 20 or more years to adequately sample the climate and other environmental variables or before a sufficiently long time span in the life of a native plant is covered. Twenty years is a comparatively short period in the life of most of our western forest trees, and 10 years in the functioning of a watershed. So far, we have not found practical means for collapsing time in many of these fields. Thus, we must foresee needs well ahead if results are to be available when they are needed for application.

Viewed from the standpoint of these considerations, our research on vegetation of forest and rangelands is substantially behind the level that should now be under way to meet the needs of even the immediate future.

SUMMARY

I close by emphasizing that we have progressed substantially in gaining knowledge about our native vegetation. But we are far from having enough knowledge to meet present demands for use in resource management, let alone future demands.

Man-caused changes in environment, presently under way and impending, will create wholly new problems or will introduce variants of existing ones. These new problems on the horizon, plus those already with us, demand a major acceleration in the search for knowledge if we are to keep pace with the rapidly burgeoning demands on the land and its protective, useful, and aesthetically pleasing cover of vegetation.

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PART II
TECHNICAL SESSIONS

TECHNICAL SESSION

Monday Afternoon—March 9

Chairman: ROBERT L. JONES
Leader, Delta Fish and Wildlife Study, California Department of Fish and Game, Sacramento

Discussion Leader: KENNETH L. DIEM
Associate Professor of Zoology and Game Management, University of Wyoming, Laramie

WETLANDS AND INLAND WATER RESOURCES

MAN-MADE CHANNEL ALTERATIONS IN THIRTEEN MONTANA STREAMS AND RIVERS

JOHN C. PETERS AND WILLIAM ALVORD
Montana Fish and Game Department, Helena, Montana

The carrying capacity for trout in streams is greatly reduced when channels or stream banks are altered by man's activities. In a study describing the relationships between trout populations and cover, Boussu (1954) reduced the number and the weight of trout in sections of Trout Creek by removing stream bank vegetation and undercut banks. In developing flood plain land, man often removes stream bank vegetation, reconstructs stream banks with riprap or a dike, or reroutes the stream into a new, shortened channel. Most of these developments reduce the amount of cover available for trout.

Whitney and Bailey (1959) recorded that the number of catchable-sized trout (6 inches or larger) in a section of Flint Creek dropped from 69 the year before rechanneling by highway construction to six the following year. Boulders have been added to the altered section to try to replace the shelter areas that were destroyed. In 1962, five years after rechanneling, Whitney[1] reported that there were only one-third as many trout in the study section.

Nelson and Hill[2] found a 75 per cent decrease in the trout population in a section of Rock Creek after it was rechanneled for flood control. They measured 17 miles of stream channel altered as a result of the flood control project. Snags and fallen logs were removed from the channel and stream bed gravel bulldozed into dikes that replaced the natural stream bank.

In 1961, Nelson and Bianchi[3] surveyed the Little Big Horn River to measure the amount of man-made channel alterations. They found that over half of this river had its channels altered by man's activities. Twelve trout streams and rivers located throughout the state were surveyed for man-made channel alterations in 1962. The results of the 1961 survey and the 1962 survey on 12 streams are included in this report.

The purpose of the stream channel alteration inventory was to measure the amount of stream channel changed by man, the type of channel alteration, and the party responsible for the alteration. For comparative purposes, standing crop estimates of the fish population were censused in both natural and altered channels in the streams surveyed.

METHODS

Aerial photographs (1 in = 660 feet) were used to measure the original length of the stream channel. Channel alterations visible on the photographs were inspected in the field, measured from the photographs with a map measure, and recorded on the photos. Channel alterations not visible on the aerial photos, or made after the photograph flight date, were measured in the field with a steel tape and recorded on the photos. In addition, all channel alterations were recorded on a field note form.

Blueprints of construction projects adjacent to rivers and streams were obtained from the Montana Highway Department and from railroad companies. The prints were examined carefully and compared with the aerial photos to verify man-made stream channel alterations. The blue-prints were useful in determining if a cutoff meander was natural or man-made and the party responsible for

[1]Personal communication from Arthur N. Whitney, Highway 93 South, Missoula, Montana.
[2]Nelson, Perry H., and Cliff W. Hill. (1960) Fishery History of Rock Creek. Montana Fish and Game Report, Helena, Montana, 14 pp. (Multilith)
[3]Nelson, Perry H., and Donald R. Bianchi. (1962) Stream channel alteration inventory. Job Completion Report, Montana, D-J Project F-20-R-7, Job IV, 4 pp. (Multilith)

the alteration. Personal contacts with residents further verified man-made alterations.

Old issue U. S. Geological Survey quadrangle maps and U. S. Forest Service maps were used also to verify man-made alterations. Only stream channel alterations that were positively assessed as man-made were enumerated in this survey.

The four types of man-made alterations measured were defined as follows:

(1) *Channel relocation* is replacement of the natural meandering with a length of man-made channel. The relocated channel has a flume-like appearance, without pools, deep holes, or undercut banks. It is shorter and lacks the well-defined areas of erosion and deposition associated with a meandering stream.

(2) *Riprapping* is placing materials other than stream bed rubble adjacent to the natural stream bank to prevent lateral erosion. Some of the more common materials observed were car bodies, stumps or logs, large angular rocks, and brush. These materials may or may not be anchored.

(3) *Channel clearance* is removal of materials occurring naturally within the stream channel such as fallen logs, stumps, or gravel and rubble.

(4) *Diking* is using natural material from the stream bed to construct an artificial stream bank.

Stream channel alterations were grouped on the basis of activities: railroad construction, road construction, urban and industrial development, and agricultural activities. No attempt was made in this survey to evaluate whether or not the alterations were preventing lateral channel erosion.

Standing crop estimates of the fish populations in the streams surveyed were made by electrofishing 4,000 square feet areas of channel. Blocknets were placed at the upstream and downstream boundaries delineating the areas of stream censused. Two sections of equal area were censused for fish in each stream surveyed: (1) a natural meandering stream channel and (2) a stream channel altered by man's activities.

RESULTS

The amount of channel altered. The greatest loss of fishing water in the 13 streams inventoried resulted from man's apparent unwillingness to allow the streams to meander throughout their natural courses. Their total length was shortened by 68 miles when 137 miles of natural stream was re-routed into 69 miles of inferior, man-made channel (Table 1). The man-made relocated channels were typically flume-like in appearance, without undercut banks or a well-defined pool-riffle complex found in a natural meandering stream.

One-third of the total length of the streams inventoried (250 of 768 miles) had been altered from their natural condition (Table 2). Four of the streams had more than one-half of their length altered. All but one of the streams had more than 20 per cent of their length altered by man's activities.

Channel relocations accounted for 55 per cent of the alterations in the streams surveyed. The remaining alterations consisted of riprapping (26 per cent); diking (16 per cent); and channel clearance (3 per cent). There were 1,987 individual alterations recorded in 768 miles of stream channel inventoried, nearly three alterations per stream mile. The average length of a channel alteration was 664 feet.

The parties responsible. The party responsible for the channel alteration was also determined and enumerated (Table 3). More than one-half of the alterations were attributed to road and railroad construction. The majority of railroad work was done prior to 1920 while state, county, and federal road construction projects were mostly of a more recent occurrence.

Agricultural activities accounted for over one-third of the channel alterations. The largest number of individual alterations were enumerated in this category. Urban and industrial development accounted for the remaining channel changes.

Fish statistics. Table 4 lists the comparisons between the fish population standing crop statistics in the censused areas of natural and

TABLE 1. THE LENGTH OF NATURAL MEANDERING STREAM CHANNEL LOST, THE LENGTH OF RELOCATED STREAM CHANNEL REPLACING THE NATURAL MEANDERING STREAM CHANNEL, AND THE RESULTING REDUCTION IN LENGTH OF STREAM CHANNEL MEASURED IN THIRTEEN MONTANA STREAMS AND RIVERS

	Miles of		
	Natural meandering stream channel lost	Relocated stream channel replacing meandering stream channel	Reduction in stream length (miles)
Little Big Horn River	52.9	16.5	36.4
St. Regis River	6.3	5.4	0.9
Ninemile Creek	0.9	0.7	0.2
Sheep Creek	3.6	2.0	1.6
Otter Creek	6.7	2.9	3.8
Belt Creek	8.6	7.2	1.4
Beaver Creek	3.5	2.0	1.5
West Gallatin River	4.4	4.1	0.3
Rocky Creek	9.3	5.3	4.0
Big Hole River	17.3	4.4	12.9
Boulder River	2.1	1.5	0.6
Prickley Pear Creek	19.2	16.0	3.2
Ashley Creek	2.8	1.4	1.4
Total	137.6	69.4	68.2

TABLE 2. THE LENGTH OF STEAM CHANNEL ALTERED AND THE NUMBER OF ALTERATIONS BY TYPE IN THIRTEEN MONTANA STREAMS AND RIVERS

River or Stream	Channel Relocation[1]		Riprapping		Channel Clearance		Diking		Total			
	Miles altered	No. of alter-ations	Miles altered	No. of alter-ations	Miles altered	No. of alter-ations	Miles altered	No. of alter-ations	Miles altered	No. of alter-ations	No. of stream miles	Per cent altered
Little Big Horn River	16.5(36.4)[1]	68	6.2	95	1.4	13	3.4	15	63.9	191	120.0	53
St. Regis River	5.4(0.9)	23	17.9	88	0.0	0	1.2	10	25.4	121	37.1	68
Ninemile Creek	0.7(0.2)	6	1.7	53	0.0	0	2.4	22	5.0	81	23.9	21
Sheep Creek	2.0(1.6)	15	0.1	9	0.1	1	0.0	0	3.8	25	12.4	31
Otter Creek	2.9(3.8)	23	0.7	18	0.5	9	0.1	3	8.0	53	34.5	23
Belt Creek	7.2(1.4)	36	3.4	55	0.3	2	8.8	66	21.1	159	81.0	26
Beaver Creek	2.0(1.5)	6	1.2	30	0.2	7	0.5	23	5.4	66	49.5	11
West Gallatin River	4.1(0.3)	20	9.5	143	0.7	13	5.6	88	20.2	264	85.9	23
Rocky Creek	5.3(4.0)	31	1.3	62	0.2	3	0.8	12	11.6	108	18.4	63
Big Hole River	4.4(12.9)	56	11.0	107	0.8	13	17.0	219	46.1	395	147.6	31
Boulder River	1.5(0.6)	14	7.9	246	1.0	21	1.4	27	12.4	308	86.3	14
Prickley Pear Creek	16.0(3.2)	21	1.0	72	0.9	31	0.1	7	21.2	131	41.0	51
Ashley Creek	1.4(1.4)	8	1.9	73	2.1	3	0.1	1	6.9	85	30.2	23
Total	69.4(68.2)	327	63.8	1051	8.2	116	41.4	493	251.0	1987	767.8	33

[1] Number in parenthesis refers to miles of stream channel lost as a result of the channel relocations.

TABLE 3. THE LENGTH OF STREAM CHANNEL ALTERED, THE NUMBER OF ALTERATIONS, AND THE PARTY RESPONSIBLE FOR THE ALTERATIONS IN THIRTEEN MONTANA STREAMS AND RIVERS

River or Stream	Railroad Construction		Road Construction		Urban and Industrial Development		Agricultural Activities		Total			
	Miles[1] altered	No. of alterations	Miles[1] altered	No. of alterations	Miles[1] altered	No. of alterations	Miles[1] altered	No. of alterations	Miles[1] altered	No. of alterations	No. of stream miles	Per cent altered
Little Big Horn River	39.8	48	2.9	22	2.0	7	19.2	114	63.9	191	120.0	53
St. Regis River	13.0	54	10.7	60	1.6	6	0.1	1	25.4	121	37.1	68
Ninemile Creek	0.1	5	0.6	24	1.9	4	2.4	48	5.0	81	23.9	21
Sheep Creek	0.0	0	3.8	25	0.0	0	0.0	0	3.8	25	12.4	31
Otter Creek	0.0	0	4.6	41	0.1	1	3.3	11	8.0	53	34.5	23
Belt Creek	1.2	10	9.3	74	4.4	28	6.2	47	21.1	159	81.0	26
Beaver Creek	1.5	3	2.7	25	0.2	10	1.0	28	5.4	66	49.5	11
West Gallatin River	0.8	6	11.8	98	0.7	26	6.9	134	20.2	264	85.9	23
Rocky Creek	3.6	7	1.6	22	1.0	26	5.4	53	11.6	108	18.4	63
Big Hole River	3.8	21	6.1	50	1.3	12	34.9	312	46.1	395	147.6	31
Boulder River	2.5	26	3.1	49	1.9	18	4.9	215	12.4	308	86.3	14
Prickley Pear Creek	3.6	26	0.4	7	14.6	24	2.6	74	21.2	131	41.0	51
Ashley Creek	0.8	9	0.7	35	1.3	3	4.1	38	6.9	85	30.2	23
Total	70.7	215	58.3	532	31.0	165	91.0	1075	251.0	1987	767.8	33

[1] Includes miles of stream channel lost as a result of the channel relocations.

TABLE 4. THE NUMBER OF FISH, THE NUMBER OF FISH SIX INCHES OR LARGER, AND THE WEIGHT OF FISH CENSUSED IN EQUAL AREAS OF ALTERED AND NATURAL STREAM CHANNELS IN THIRTEEN MONTANA STREAMS AND RIVERS

River or Stream	Channel Type	Number of				Number of fish 6 inches or greater				Weight of			
		Trout	Whitefish	Others	Total	Trout	Whitefish	Others	Total	Trout	Whitefish	Others	Total
Little Big Horn River	Natural	76	5	0	81	26	5	0	31	13.7	3.0	0.0	16.7
	Altered	37	1	9	47	1	1	1	3	1.6	0.0	0.4	2.0
St. Regis River	Natural	22	35	19	76	9	35	0	44	4.1	19.8	0.6	24.5
	Altered	6	5	39	50	5	5	1	11	0.8	1.5	1.7	4.0
Ninemile Creek	Natural	65	0	11	76	17	0	0	17	4.3	0.0	0.0	4.3
	Altered	13	0	14	27	0	0	0	0	0.6	0.0	0.0	0.6
Sheep Creek	Natural	35	40	0	75	9	33	0	42	2.4	4.7	0.0	7.1
	Altered	1	0	4	5	0	0	0	0	0.1	0.0	0.1	0.2
Otter Creek	Natural	16	0	75	91	14	0	60	74	8.5	0.0	22.0	30.5
	Altered	1	0	16	17	1	0	11	12	0.4	0.0	4.2	4.6
Belt Creek	Natural	2	3	6	11	1	3	5	9	0.2	2.4	1.8	4.4
	Altered	0	0	16	16	0	0	2	2	0.0	0.0	0.9	0.9
Beaver Creek	Natural	88	0	12	100	17	0	12	29	5.6	0.0	1.7	7.3
	Altered	3	0	5	8	0	0	0	0	0.1	0.0	0.6	0.7
West Gallatin R.	Natural	6	16	10	32	6	15	10	31	4.4	14.6	20.9	39.9
	Altered	1	11	0	12	1	11	0	12	0.1	7.2	0.0	7.3
Rocky Creek	Natural	63	13	59	135	62	13	54	129	29.3	12.9	50.7	92.9
	Altered	55	0	28	83	24	0	24	48	5.0	0.0	4.9	9.9
Big Hole River	Natural	17	68	46	131	14	63	45	122	9.0	26.3	13.8	49.1
	Altered	1	0	2	3	0	0	1	1	0.1	0.0	0.1	0.2
Boulder River	Natural	41	1	0	42	22	1	0	23	4.2	1.3	0.0	5.5
	Altered	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0
Prickley Pear Cr.	Natural	19	0	45	64	11	0	38	49	5.5	0.0	23.5	29.0
	Altered	13	0	52	65	5	0	48	53	1.7	0.0	23.7	25.4
Ashley Creek	Natural	0	0	86	86	0	0	26	26	0.0	0.0	5.8	5.8
	Altered	0	0	54	54	0	0	0	0	0.0	0.0	0.4	0.4
Total	Natural	450	181	369	1000	208	168	250	626	91.2	85.0	140.8	317.0
	Altered	131	17	239	387	37	17	88	142	10.5	8.7	37.0	56.2

altered channels. In the natural meandering channels, the total number of trout and whitefish made up nearly two-thirds (62 per cent) of the standing crop. In the altered channels, trout and whitefish made up only one-third (32 per cent) of the standing crop. There were over 5½ times as many trout and nearly 10 times as many whitefish censused in the natural channels as in the altered channels. Six of the 13 streams that had trout 6 inches or larger in their natural channels had no trout 6 inches or larger in their altered channels.

Comparing the total weight of all fish in the natural channels to that of the altered channels disclosed: (1) the total weight of all fish species was over 5½ times greater in the natural channels; (2) the total weight of the trout and whitefish combined was over 9 times greater in the natural channels; and (3) in each stream, there was a greater total weight of fish in the natural channels.

DISCUSSION

Economically, a trout stream can be considered as a self-sustaining, long-term capital investment. McConnen[4] reported that fishermen in Montana in 1960 spent $36,300,000 pursuing their sport. This money can be thought of as the interest from the capital investment, the fishing waters in the state. Bishop[5] reported that two-thirds of Montana fishermen prefer to fish in streams or rivers. We can only speculate on the dollar value of the stream trout fishery in the year 2000 (U. S. Department of the Interior, 1962). The loss of the fishing dollar to the economy, now or in the future, would affect everyone in the state, including people who do not fish.

The statewide stream channel alteration inventory pointed out that channel alterations in trout streams and rivers are abundant throughout the state, and altered channels do not support nearly as many fish as do natural meandering channels. Our capital investment principal decreases every time another section of stream channel is altered.

Recently, channel alterations by road construction projects have received criticism by resource managers. However, this inventory points out that railroad construction; urban and industrial development; and agricultural activities, in addition to road construction projects, have altered many miles of streams. The implications of the effects of channel alterations for resource use have been summarized in Berryman *et al.* (1962).

Part of the money spent by man on flood plain development is

[4]McConnen, Richard J. (1961) Economic importance of hunting and fishing in Montana, Montana Fish and Game Report, Helena, Montana, 13 pp. (Multilith)
[5]Bishop, Clinton G. (1959) Statewide creel census. Job Completion Report, Montana, D-J Project F-4-R-8, Job III, 9 pp. (Multilith)

from tax money. For example, all the money spent on road construction comes from the federal, state, or county tax dollar. The Agricultural Conservation Program of the Department of Agriculture partly subsidizes channel alteration programs for flood control. These programs are legal instruments, an integral part of the law of the land.

Legislation is needed to protect our trout streams from further channel disturbances. The growing demand for outdoor recreation is a nation-wide cause for immediate concern. The economic benefits of sport fishing to a community or state are large and justify the need for protective legislation. Unfortunately, a dollar value can not be placed on the enjoyment derived from fishing.

SUMMARY

There were 1,987 individual alterations in the 768 miles of stream channel inventoried. As a result of the man-made alterations, the length of the channels was shortened by 68 miles. Agricultural activities accounted for the greatest length of channel altered followed in order by railroad construction, road construction, and urban and industrial development. Relocated channels accounted for the greatest length of channel altered followed in order by riprapping, diking, and channel clearance. Standing crops of game fish were several times more abundant in natural, meandering channels than in altered channels.

ACKNOWLEDGMENTS

In each fisheries management district, at least one stream was surveyed for stream channel alterations by fisheries biologists and their summer crews. The interest and enthusiasm generated by these biologists stimulated this written summary of the statewide inventory. Perry H. Nelson and Lloyd Casagranda, Montana Fish and Game Department Information and Education Officers, contributed in many ways toward implementing and coordinating this project.

The investigation was conducted under the Dingell-Johnson Program in Montana.

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DISCUSSION

VICE CHAIRMAN DIEM: Mr. Peters has defined the problem rather graphically. It is, unfortunately, a common problem to too many states in our country.

Having a problem defined in such a manner as this, what has the State of Montana done and what legislation has been developed to cope with this problem?

MR. PETERS: We proposed that in the 1963 legislature a stream preservation act be passed and made law. We are fortunate that we had a real active Junior Chamber of Commerce, not wildlife people or people interested in wildlife specifically, but a civic organization that carried the ball for us.

Unfortunately, the legislature gave this act to us for only two years, but it is a start. It is up for renewal in 1965 and we are having to go through the same battle then.

I might also point out that because of this activity of our Junior Chamber of Commerce they are up for a national award in the field of conservation.

The law is up for renewal in 1965. It affects only the state agencies and excludes the State Water Conservation Board. However, it does force, for example, any highway department to ask us what damage a particular project would do to a stream. We base our analysis on economics, the worth of the fishery as we see it. We also see what local support we can get, and, as a result, we have saved a couple of real fine streams thus far.

MR. DEAN MARRIAGE [Oregon]: I would like to ask Mr. Peters if in his consideration of the channel changes he has established any average relationship in regard to production per unit area. I also want to know what consideration he has given to recommendations for stream improvement where a stream is going to be changed.

MR. PETERS: I will answer your second question first.

Absolutely nothing and, of course, this bothers me. We are starting to evaluate large hydraulic structures—to see if we can give a constructing agency a way of mitigating the loss to a channel that is to be encroached upon.

To answer your first question, we have not measured any of the ratios that you asked about. Therefore, we have no information on that.

Incidentally, we do have some good ideas with regard to the law and did have data from the States of Washington and Oregon. However, these, to the best of my knowledge, are the only two states that are interested legally with this particular problem.

MR. PHIL COSPER (Arizona): I believe you said that the Highway Department, for instance, had to ask for review. I'm curious in the event that you do not agree how your differences are mediated.

MR. PETERS: There is arbitration in connection with this law. They supply us with a form telling us about the projects. We have 30 days to review this project and tell the Highway Department to go ahead with it or not to go ahead with it, because we think the following things should then be incorporated. This may involve the stream proper or possibly rerouting the proposed highway. They then have ten days in which to answer. If they say that they are not going to do it, then it goes on for arbitration. One arbitrator is chosen from the Highway Department or other constructing agency, the second by the Fish and Game Department, the third is chosen by these two people and he has to be agreed upon by both.

RESEARCH IN HYDROLOGY OF FORESTED HEADWATERS AT THE COWEETA HYDROLOGIC LABORATORY

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I count it an opportunity to bring before this group the work of the U. S. Forest Service at the Coweeta Hydrologic Laboratory in western North Carolina. When it was suggested that I present a resumé of past work and future plans for the program there, I was at a loss how to begin to summarize the work of 30 years, and at the same time relate it to the interests of wildlife and conservation people. Then it came to me that it was simpler than I thought, since the ultimate interest of this group—the wise and productive use of renewable natural resources—clearly overlaps the interest which supports watershed research at Coweeta and elsewhere in the Forest Service.

Water, the universal raw material, is the common element which draws together all who are concerned with the conservation of natural resources. A point sometimes overlooked is that good resource management and good water management are often the same, right down to particulars. This is obvious enough in relation to misuse of land by overgrazing or exploitive agriculture, or the management of streams for fish, but I really mean more than this. Human activities on the land always have some influence on the water resource. Whether the activity is road construction, timber harvest, grazing, building, sewage disposal, camping, or just hunting, the effects will eventually appear in some way in the quality, quantity, or timing of the water flowing from the land. All over the world it is possible to classify the degree of use or misuse of land by examining the condition of the streams, ponds, and lakes below. At the risk of belaboring the point, I would like to put it another way and perhaps introduce another thought; i.e., any continuing activity which damages the water resource cannot help in the long run but damage the total productivity, usefulness, and beauty of the land. Thus we have in water a sensitive indicator of the long-term success or failure of land management programs and resource conservation.

By the water yardstick, I am afraid we have to admit that man has not done well in the Southeast over the last 300 years. Mud and filth in the major rivers have increased steadily over the centuries. Floods, a loose term meaning any flow of water which does damage to human property, have also increased. Row-crop farming has improved and is no longer the source of sediment it once was, but other damaging influences associated with increasing population and mechanization have emerged. The human activities which lead to water resource damage are great in number and complexity, and it is fortunate for me that I am discussing today only the headwater hydrology of forested mountain and piedmont lands.

These forested or semiforested lands are the source of most of the clean surface waters remaining in the Southeast for use by industries, municipalities, agriculture, and recreation. Most scenic rivers and lakes lie within or are fed by water from these areas. Steady operation of the giant TVA system is maintained chiefly by forest waters, and the headwaters of nearly all major rivers originate in forest land of one kind or another.

Preservation of some of these lands as national forests was assured by the Weeks Law in 1911. Part of that law stated that preservation was necessary "for regulation of the flow of navigable streams." At that time, the new Forest Service was vitally involved in questions about the effects of forests and forest management on water. However, it was not until 1933 that this concern took the form of a research program at Coweeta. Begun during the days of the CCC's, the early program of measuring rainfall and streamflow from many small forested watersheds was unique in its scope and purpose. The 5,000-acre basin was ideal for field experiments on water and forest. Located in the hardwood forests of the southern Appalachians under the heaviest rainfall east of the Mississippi, the area has plenty of the hydrologic materials needed for study—lots of forest, storms, soil, and above all, lots of water.

Before 1933, studies of the influence of forest and man's use of forest on water had been characterized by opinion and guesswork. Only two notable efforts to measure precipitation and runoff from forested catchments had ever been made, one beginning in 1895 in Switzerland and one in 1911 at Wagon Wheel Gap in Colorado. The latter was a joint study by the Forest Service and the Weather Bureau stimulated by congressional controversy over the Weeks Law. These two pioneering efforts taught us something of the complexity of streamflow from small watersheds and showed that man's old conviction that forest cover increased total streamflow was probably not true. Students of the transpiration process were reasoning by 1900 that forests must evaporate more water than pasture and farmland, and therefore must eventually reduce streamflow. Foresters entered the controversy and appeared at that time to be first on one side and then on the other of the question, chiefly because the ideas of *quantity, quality,* and *timing* of streamflow were seldom defined or separated during discussions by laymen or technicians. Most informed foresters then and later were aware that mature forest cover reduced total water yield. However, foresters were committed to the proposition that forest was essential to preserve water quality and to stabilize streamflow. These were, after all, the immediate water problems at that time.

Then, through population expansion and greater per capita use, water supplies of some regions began to show signs of seasonal shortages. The question, "Does the presence of heavy vegetative cover reduce total water yield?" finally led the Forest Service to make some actual observations. Everyone knew that a whopping two-thirds of all our rainfall is lost to streamflow and ground water by evaporation. The evaporative process is so complex that the only study method then available was measurement of precipitation and streamflow before and after changes in land management. The Coweeta research program was based originally on this approach, and by 1950, several classic experiments had yielded much new information about the effect of forest on streamflow.

For example, several forested watersheds were deliberately abused by bad farming, logging, and grazing practices. The movement of silt and rocks, and the change in timing of streamflow were measured and shown to be even greater than expected. Such small watershed experiments revealed a complex pattern of slow destruction of the land and water resources. Not only the total yield and quality of water but the all-important timing of delivery were affected by poor management. Destruction of protective vegetation, trampling by cattle, and careless road building produced a feast-and-famine type of water supply. This is an old story now, but as time went on water yield and quality emerged as one of the great potential assets of these well-watered areas of stable soil and vigorous vegetation.

In one early experiment, complete clear felling of all trees and shrubs produced an unmistakable increase of 16 area inches the first year. This is equivalent to more water than falls as total precipitation in a quarter of the land area of the United States. Water supply people were interested to find that late summer streamflow was more than doubled and that increases persisted for many years. Even though no roads were built and no timber harvested in the experiment, many expected the land to come apart and wash away following the drastic cutting of forest. But there was no change in water quality or timing of flows because the highly permeable soil conditions were maintained by vigorous regrowth. Of course, this increase after felling the forest was brought about on a unit already producing 32 inches of water per year, and in an area which has a large surplus of water anyway. However, further experiments at Coweeta and other

Forest Service units verified the conclusion that total yield and timing can be changed substantially by drastic changes in forest cover. Annual yield increases from 4 to 17 inches have been measured following complete felling of mature hardwood forest. As the forest regrows, yield gradually decreases to former levels, a process lasting from 5 to 40 years depending on the size of the initial increase.

Are these increases after cutting economically important? For the most part they have not been in the past, or at least we have not appreciated their importance. We are already talking about producing fresh water from salt at costs of not less than a dollar per 1,000 gallons, to which must be added the cost of pumping it uphill. At Coweeta, we produced much cheaper, much purer water, already at an elevation of 2,000 feet. The real answer appears at this time to depend in a complex way on transportation of increased water from the area of production to the point of use or need. If it becomes economical to pipe water from the southern Appalachians to the cities of the plains, the way oil is pumped the other way, the production of extra water in surplus areas would take on new meaning. As an example of the hydrologic advantages of elevation, Switzerland is already selling fresh water to Germany on a large scale. The Germans are even assessed part of the cost of maintaining Swiss watersheds.

But there is perhaps a more immediate question for research. We do not yet know exactly how these increases in yield were brought about on the experimental units. Apparently, increases can be demonstrated on some small watersheds but not on others. The result is that we can tell a watershed planner that water flows will tend to increase after any substantial reduction of vegetation, but cannot tell him just how much, or just when it will come, or how long it will last.

Lacking a reliable prediction method, forest managers and engineers are hard put to make wise use of our information. Only a few municipal and industrial watershed managers in the East have listed increasing water yield as one of the objectives of management. Because of the complexities of water measurement, even this few have no really good way of calculating cost-benefit ratios. Nevertheless, plans for reducing forest cover on a grand scale have been pushed vigorously and unwisely in some areas on the mere promise of increases.

Why can't we predict accurately and confidently the influence of land cover conditions on water yield? By long-term experiments on paired watersheds, we are able to account for some of the climatic variation from season to season, but the variation between watersheds and different types of forest is another matter. One way is to repeat watershed experiments perhaps ten times in various sections of the country. But the cost of such experiments has run from 50 to 100 thousand dollars each. To top it off, there are very few small basins on which precipitation and streamflow can be measured accurately enough to experiment with total water yield. The greatest problem which has emerged from past watershed research is how to extend what we find on one carefully selected experimental catchment to other catchments.

After a few pilot efforts to apply what we had learned about water yield and quality to actual management situations in the Southeast, we were forced to conclude that not enough was known about the physical processes controlling streamflow to write orderly prescriptions for managing forests for water. About five years ago a new phase of the program began, organized now along more fundamental lines, and less dependent on experimental watersheds. Where once we wanted simply to know *what* happened to water flows when forest cover was changed, we now wish also to know *why*. Part of this new program has taken the form of an effort to trace and explain on a physical basis the movement of rainfall from the clouds to the stream channel, or back to the air. It is not enough simply to diagram this cycle; we seek a better understanding of the location and physical state of water, and the forces causing it to move up into the air or down into the stream. Far less is known about these headwater processes than we sometimes assume. It is within these upstream areas that land management practices either waste or conserve water supplies.

In small watersheds the processes that control water behavior can be classified into four overlapping areas of investigation. These have to do with the physics of water behavior in the air, in plant cover, in the earth mantle, and in streams. These four fields provide a convenient framework upon which to organize a team of researchers covering a wide scope of specialties. Our present team of six professionals has found it an effective way to gain some depth in our research effort. Under present plans, we are training or attempting to recruit a forest climatologist, a plant physiologist, a forest soil physicist, and a forest hydrologist. These investigation leaders will be supported by a staff including some specialization in forest engineering, stream biology, mathematics, electronic instrumentation, and geology. Through cooperation with neighboring universities and agencies, such a staff will be able to maintain a high level of technical proficiency and provide some new solutions to old problems of watershed management.

Despite limitations in facilities—a proper laboratory building is still in the planning stages—the new program is beginning to pay off in better understanding of the nature of water movement in forested mountain land. Physicists have taught us how to parcel out evapotranspiration losses approximately between seasons by use of energy-balance calculations. Within seasons, water loss from hardwood forests can be attributed to four types of evaporation: (1) transpiration, (2) interception loss from crowns of trees and shrubs, (3) evaporation from litter on the forest floor, and (4) evaporation directly from mineral soil or rocks. In southern Appalachian forests, we now estimate that transpiration accounts for about 56 percent of the annual loss. Interception loss and evaporation from litter accounts for another 42 percent, and evaporation from soil, only 2 percent. So we see that under humid conditions, only a little over half the loss of vapor from forest is transpiration. About 44 percent evaporates directly from wet plant surfaces and soil following frequent rainfall. We have measured root concentration in the soil and the depths from which forest withdraws water throughout the growing season. Soil moisture under these forests, measured by nuclear methods, is plentiful the year around. With plentiful soil moisture, the water use by forests is mostly due to the heat received and retained. Dense forest is a good heat trap, particularly when wet following rain. We are now using tethered balloons to float net radiometers over forests, trying to compare evaporative efficiency from the amount of heat soaked up by different stands at different times.

From these and other studies we are beginning to put together a better picture of the evapotranspiration process in humid areas. During forest management in humid regions, it is mostly by changing the amount and structure of vegetation that total vapor losses are changed. The physiologic behavior of plants controls transpiration to some extent directly. But it is the arrangement of the vegetative parts—i.e., whether they are large or small, tall or short, dense or sparse, rough or smooth, deep rooted or shallow, standing or down—that determines a great deal of the evaporative efficiency of the stand. Vapor losses result from the availability both of water and of the heat to vaporize it. The efficiency of forest in trapping or reradiating heat is related strongly to its surface roughness, depth, density, and other structural factors. Structural development and growth of the forest stand bring more water within easy reach of evaporating processes for longer periods of time. In future we will be studying the structure of forest stands more carefully to determine how we alter seasonal and total water yield in humid areas by ordinary management practices.

Vegetative structure is not the whole story, however. It is possible to attack the transpiration process directly. Some recent studies by plant physiologists indicate that transpiration may be reduced non-destructively by chemicals which cause the tiny breathing pores of leaves to close. Stomatal closure is virtually the only physiological activity of plants known to influence vapor loss directly. If chemically-induced stomatal closure were to become practical on an acre basis, drastic structural changes might not be required to bring about increases in water yield. The Coweeta watersheds will be used to test transpiration inhibitors and to determine if there are undesirable side effects on forest growth and water quality.

Watershed shape and structure are certainly part of the story also. Recently we began some research which seeks to find out, among other things, why two neighboring watersheds, which appear alike, may often yield water quite differently. This has led us to the study of water movement underground. By measuring drainage from large sloping models—one is 200 feet long and 7 feet deep—we have concluded that normal streamflow in humid mountain areas is fed primarily by slow drainage from *unsaturated* soil, rather than from ground water aquifers. The slope, depth, and location of soil masses are the key to understanding how small watersheds operate in releasing water downstream. These ideas alter conventional concepts of ground water and are particularly applicable to the Appalachians, but the principle probably applies elsewhere. We have not yet fully evaluated the importance of this finding, but see in it an opportunity to reduce guesswork in predicting flows from small watersheds. Subsurface and surface morphology of catchments also affect the structure of forest cover and thus indirectly influence vapor losses. Knowledge of how water moves underground to small streams will help predict or avoid pollution of water by insecticides, herbicides, and even radioactive materials. In a recent cooperative study with the Public Health Service on the Coweeta basin, we obtained evidence that the pattern of DDT application on the area made the difference between no detectable DDT in the water and a continually decreasing concentration of DDT for six months after spraying. The "filtering power" of a watershed is related to the depth and location of the soil masses and the velocity of water through them. We know from studies of soil moisture fluctuations and the physics of flow through porous materials that rainwater moves very rapidly through some portions of watersheds, but very slowly through other portions. We must learn how to take advantage of these relations in writing prescriptions for management.

These fundamental studies require more and more refined techniques and talents. In many areas we are up against the limits of our understanding through older methods and approaches. New instrumentation is playing a large role in the program. But we have not given up experimental watersheds as a means of applying what we are learning to management situations, nor have we extracted all there is to learn from rainfall and runoff measurements on small watersheds. The watershed is still the ultimate testing ground. The traditional large-scale watershed treatment continues at Coweeta, but primarily as pilot tests of ideas which have arisen from previous research.

One such pilot study is underway on a 360-acre watershed to demonstrate a management scheme under the multiple use concept. An analysis of the resources of the unit showed that the primary uses over the next 50 years (at least) would be timber, water, wildlife, and recreation, more or less in that order. The catchment was divided into compartments for intensive management, some for timber, some for water, and some for both. A complete and permanent forest access system was designed and constructed to serve all areas and all uses of the forest, including hunting, fishing, and recreation. Part of the plan is to increase the net return from all these uses to a maximum, and to determine by actual experience which practices tend to conflict with each other under total management.

One outcome from the attempt to apply the multiple use concept on a model basis was the surprising degree to which management objectives for several uses can be made to coincide. Sometimes a single operation, such as clear cutting, will serve several purposes. For example, the timber in some compartments was stagnant and overmature, water was wasted by unproductive trees, forage within the browse level was scarce, and the trout stream was inaccessible and clogged with debris. Populations of deer, turkey, grouse, and squirrels were limited. By clear cutting some areas and thinning others, we are simultaneously increasing water yield, putting growth on better trees, reproducing more vigorous stands, providing masses of forage and edge areas, and opening up roadways for grass seeding and hunter access. Permanent, practically maintenance-free access has been provided by careful planning and construction. Wherever possible, visitors and trail walkers have been steered toward high ground, away from critical stream areas. Nearly all types of game should be benefited by opening up portions of the stand. The few conflicts that exist can be solved by determined management. Whether we come to such intensive management or not is for the future to decide, but here we are trying to blend objectives together and apply management on a catchment whose hydrology we think we understand well enough to predict a successful outcome.

Logging roads and timber harvesting in the mixed-wood forests of the East are no longer thought to be a serious cause of raging floods, but too few realize the damage that careless activities around streams produce in the fish habitat or in the quality of drinking water. A little careless logging every ten years can keep enough silt and debris moving to ruin a good trout stream, or to require expensive processing before human use. On the other hand, few realize that careful management can actually benefit fish and game through favorable influence on environments. Management to increase water and timber in humid forests produces the type of disturbance so important for variety in forage and game populations. If done with some skill, better water, timber, and recreation management is not too different from better game management.

To repeat a basic premise, the success or failure of any program for managing forest and wild land rises or falls with the long range effect such management has on the water resource. Although this might be argued in some cases on economic grounds, it is often noted that all common abuses which lead to damage of soil, vegetation, and animals, lead also to damaged water resources. Bad forest practices which destroy site and timber stands are often practices which destroy streams and the beauty of forests. To list several examples, unprofitable woodland grazing starves cattle, impairs timber values, and pollutes water. Erosion that destroys soil productivity or road surfaces also ruins streams for fish, for human use, for beauty. Bad road location or construction can lead to poor access for protection, for timber stand improvement, for game harvesting, and even to destruction of the road itself. Programs to manage the natural resources of wild land should always be carried out with an eye on the hydrologic facts of life, and we should oppose anyone who plans under pressure of expediency to adopt practices damaging to present and future water resources.

DISCUSSION

DR. WILLIAM SHELDON (Massachusetts): I have a few questions that are of particular interest.

You spoke of the possibility of reducing transpiration by applying chemicals which close the breathing pores. Is this a toxic chemical that kills the trees?

DR. HEWLETT: According to the latest research on the subject by Dr. Waggoner at Connecticut, these are metabolic inhibitors which will affect the closing process of the stomata without affecting the functioning of the leaf.

DR. SHELDON: One other question. You made some comment about the pattern of DDT and its appearance in streams. Would you mind repeating what you said about that?

DR. HEWLETT: Perhaps it would help if I described it a little more completely.

The basin which you saw in one of the slides contained about 5,000 acres and during one year there was an outbreak of the elm spanworm, defoliating much of the timber, primarily on the ridges. The first year this spray was used at about half a pound of DDT and oil per acre and, during that year, the Public Health Service and we ourselves maintained a continuous operating sampler at the outlet to the watershed. For about six months following the spray operation, there was a continually decreasing concentration of DDT in the stream water.

The following year, we used helicopters and sprayed only the areas most seriously affected by the elm spanworm, which were the ridge tops. This amounted to spraying about one-quarter to one-third of the area we had sprayed the previous year and this was restricted to upstream areas. It is of interest to know that in the spraying with the helicopters, the stream density was four miles of stream per square mile of land area. When the whole basin was sprayed, the stream density was about seven miles of stream per square mile of area. In addition, the streams were smaller. The amount of DDT that had gotten into the streams as a result of the pattern spraying did not show up in the very sensitive sampling method which the Public Health had developed for these problems.

VICE CHAIRMAN DIEM: Thank you very much, Dr. Hewlett, for a very stimulating discussion on some new developments, which gives us a new field of research which has unlimited possibilities for quality control of water.

DEVELOPING FISH AND WILDLIFE RESOURCES THROUGH PUBLIC LAW 566 PROJECTS

ALBERT M. DAY

Executive Director, Pennsylvania Fish Commission, Harrisburg

Providing outdoor recreation for a burgeoning population with apparently insatiable appetites for fishing, hunting, swimming, camping, hiking, skiing and the like, is a growing problem.

Ninety percent of all Americans take part in some form of outdoor recreation every year. One quarter billion acres of public land are involved. An equal acreage of private land is similarly involved. Consumers spend about twenty billion a year on outdoor recreation in one form or another year after year. Federal, state and local governments spend about one billion a year in providing recreation. In the past decade, the use of state and federal recreation acres of various sorts has increased by 90 to more than 300 percent.

Under those pressures ancient concepts of land and water management have gradually fallen by the wayside. New philosophies have emerged. The values of public forests are no longer measured by the board feet of lumber produced. Our public domain is no longer looked upon as a private preserve for the grazing of cattle and sheep. Dams built across our great river systems to generate hydroelectric power, control floods and to provide navigation now include fish and wildlife benefits due in large part to the Federal Coordination Act.

Attitudes of construction engineers have shown a rather remarkable change in the past ten years. Planners now recognize the advantage of having the great body of outdoor enthusiasts support their programs. They now realize that if trout fishermen are disappointed because stretches of their favorite streams disappear behind the dams, as many or more warm-water fishermen soon take their place; plus pleasure boaters, water skiers, swimmers and picnickers.

One of the most effective tools of integrating the needs of this variety of interests is the Small Watershed Act under Public Law #566. It is administered by the Soil Conservation Service of the U. S. Department of Agriculture. It provides a means by which local, state and federal groups can work together to jointly develop our natural resources of soil and water, woodlands and wildlife, while at the same time effectively accomplishing its primary function of flood control in headwater areas. The program creates a partnership between the people and their governmental agencies for solving some of the more comprehensive jobs in conservation which generally cannot be solved individually or by smaller groups. Basically the small watershed program provides for land treatment measures to prevent soil erosion and for building structures to impound flood waters at strategic points on headwater streams. Since the basic law was passed in 1954, several amendments have been added which are highly important to all of us interested in improving and developing fish and wildlife resources for recreational use.

An amendment in 1958 proved to be a real milestone in developing new inland waters. Commonly known as the Fish & Wildlife Amendment, this feature of the law permits the Federal Government to cost share in the development of permanent lakes behind flood prevention dams. The multiple use of these dam sites not only brings about new bodies of water, but they are much more economical than similar facilities in a single-purpose site.

This act places the initiative upon the local people to determine whether they want the benefits of a watershed program. It also requires that they share in the cost as well as the planning of the various phases of each project. This democratic process of developing our land and water resources has caught the imagination of many groups in Pennsylvania.

We are blessed with an abundance of water—we have an annual rainfall of more than 42"—but in many sections of my State we are rapidly running out of good water storage sites. Factories, houses, roads and other community services are rapidly moving in on the few good water storage sites which remain.

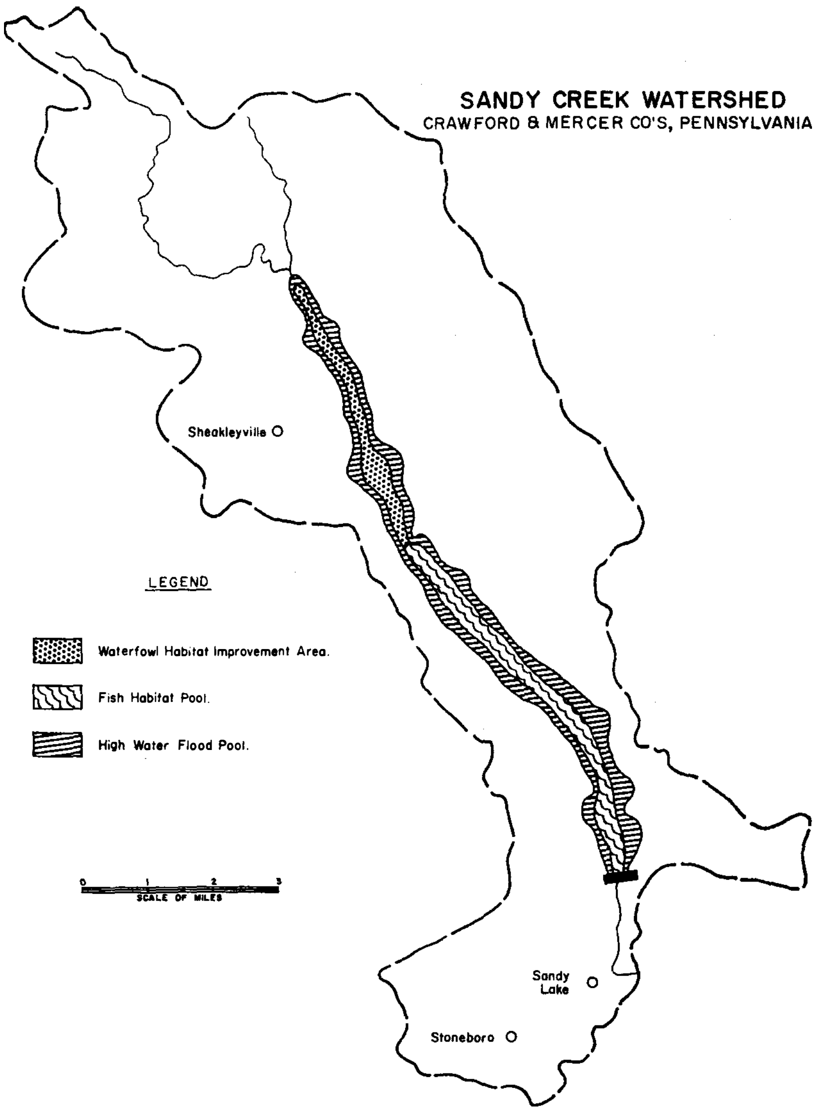

FIG. 1.

Wise planning of our water and related land resources is a major concern to us in Pennsylvania. We are located in a strategic spot to accommodate the growing demand for recreation. With our turnpikes and freeways, we lie within a few short hours of Boston, New York, Washington and the Carolinas. We have 45,000 miles of flowing streams; 30,000 miles of rivers, many natural lakes and more than 4,000 impoundments.

We have beautiful mountains that provide summer recreation, autumn hunting and one of the nation's greatest deer herds and year-round fishing. We are building new facilities for summer swimmming, golfing, boating and related sports. Winter skiing, skating and ice fishing add to the Commonwealth's growing attractiveness to year-round tourist trade. Water is the powerful magnet that draws outdoor recreation to any area.

These are among the many reasons why the people of Pennsylvania voted to spend 70 million dollars for the acquisition of land needed for reservoir sites, recreation areas, parks, fish and wildlife and related outdoor activity.

Size-wise Pennsylvania is small. It ranks 34 in the nation, but it is third in population and is a leading industrial state. Mines, cities, factories and people are jammed tight in many parts of the state, but elsewhere we have great stretches of beautiful forested hills.

We are saddled with the job of cleaning up some of the abuses of earlier generations but we are making commendable progress. Abandoned acid-producing mines are being controlled. Industrial and municipal waste treatment plant construction is on the increase. We have been able to clean up some of our silt laden streams. As a result of stream improvement programs, I am happy to report that fishing has returned to a number of areas—"uninhabitable" a few short years ago.

Not only are these new waters providing many hours of recreation to fishermen, but they are used by swimmers, boaters, picnickers and campers. They are helping to take the pressure off the other waters which are now heavily used.

Public Law #566 offers a real opportunity to accelerate this task and the Pennsylvania Fish Commission is taking advantage of it to the full extent of our financial ability. In cooperation with local sponsors we have participated in the planning for fish and wildlife development of 11 multi-purpose projects. These include 13 reservoirs which will store more than 4,500 surface acres for fishing and waterfowl. All of these lakes will be stocked and managed by the Fish Commission. Three of these multi-purpose dams were built last year and are now filling. Seven hundred and fifty surface acres of new water for fish will become available in the 3 dams. They will be of significant benefit to outdoor sportsmen as well as to the businesses which provide their needs, including food, gear and shelter. In addition, these dams play an integral part in controlling floods for which they were primarily intended.

A typical example of cooperation and maximum development within minimum resources is the Sandy Creek Watershed in Mercer and Crawford Counties. Here the sponsors want flood prevention, farm conservation work, a state park, a lake for fishing and wildlife and recreation facilities. All of this would require a number of skills located in different agencies having these assigned responsibilities.

Four state agencies, 2 federal agencies, 2 county governments, 2 soil and water conservation districts, 2 boroughs and 5 townships worked together in developing this project. When completed each sponsoring group assumed some portion of the $1,600,000 project. Sponsors below the federal level assumed over a quarter of a million dollars of responsibilities. The project provides for 5,000 acre feet of flood water storage and a 1,700 acre lake for fish and wildlife

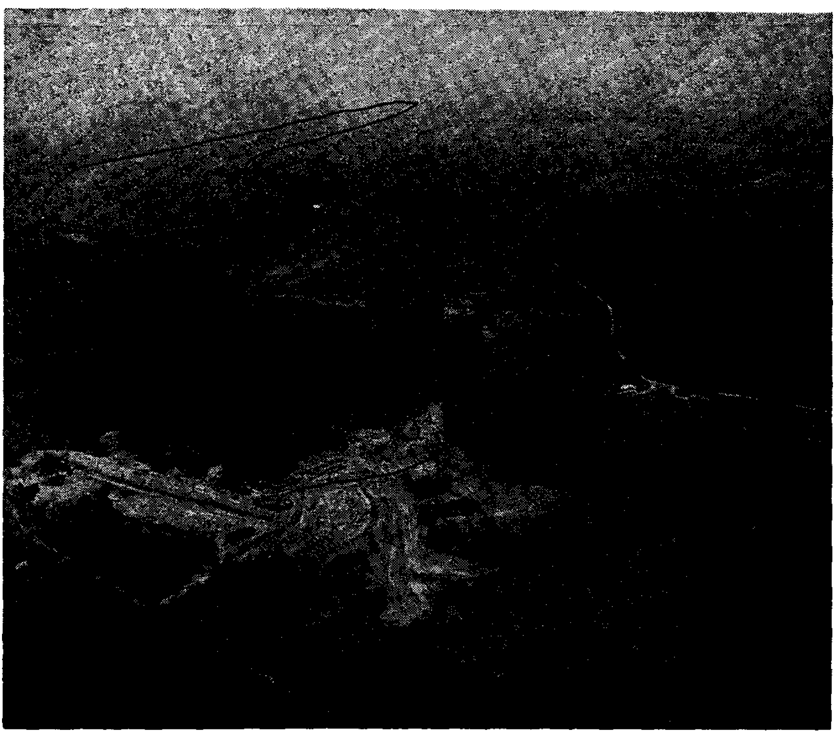

FIG. 2. Lake Tamarack. Two dams, one on Mill Run and one on Mud Run, have created this new 575 acre fishing lake.

development. It also includes a park and other water-related recreational facilities.

Another is Tamarack Lake in the extreme northwestern part of Pennsylvania. This magnificant lake is located on the headwaters of Mill Run and Mud Run just above the city of Meadville. Periodic floods have caused severe damage and created an annual cost from floods of approximately $22,500.00. Completion of the dams at Tamarack Lake now provides insurance against a repetition of these damages. This lake is located in an area with much fishable waters which are already over-taxed by fishing pressures from Erie, Pittsburgh, Cleveland and other places near and far. There are growing demands here as in most other places in the Commonwealth for more recreational opportunities.

The Pennsylvania Fish Commission joined in the planning of this Public Law #566 project and purchased 825.33 acres of bottom land on the 2 runs where centuries-old beaver dams have created a rich muck and bog soil covered with pine, birch, willow and tamarack. The Commission purchase provides complete ownership of the lake plus a perimeter strip of approximately 200 ft. above the normal pool level to guarantee full public access around the lake.

Local sponsors of the project were the Crawford County Board of Commissioners, Crawford County Soil and Water Conservation District and the Pennsylvania Fish Commission. The U. S. Department of Agriculture Soil Conservation Service was the federal agency responsible for the project. Federal funds available under Public Law #566 were used to build these dams, one on each run, and to clear the impoundment area. The Fish Commission's share, other than for land, included parking facilities, boat launching ramps, sanitary facilities, roads and public utility relocations.

The Fish Commission's expenditures were $61,689.00 for the purchase of the land. In addition $67,997 was spent for our share of clearing and construction, engineering services, relocations of a power line, parking and related facilities. This brings the Commission's participation to $129,686.00. Approximately $20,000 was expended by Crawford County.

The Soil Conservation Service's share of cost amounted to $250,554.00 for construction of the dam and other related facilities. The entire cost of the project was $400,240.00.

The future of this lake will more than repay the investment. The city of Meadville gets flood protection, fishermen and boaters get a lake with tremendous potentials. Already land values surrounding the impoundment have increased several times. The Commission has secured a new fishing lake of approximately 575 acres, at a cost of approximately $225.00 per surface area. The average cost of creating a surface acre of water on 8 lakes under our Dingell-Johnson program during the past ten years has been $1,725.00.

We are confident that multiple use of lakes reaps multiple benefits and for the future of Pennsylvania it is a must. I predict that Tamarack Lake will be one of the hottest spots in the east for muskies, walleyes, bass, pike and panfish within 5 years. Come and see!

In the overall we feel that Public Law #566 offers a real opportunity for all interests in conservation—flood control, soil, water, fish, forests, wildlife and general recreation. It is good administration for conservation agencies to join hands to meet the ever growing demands of our recreation-minded public.

DISCUSSION

MR. DOLL (Wisconsin): I realize the need for this additional recreation resource but I have a question that is bothering me and I am sure it is bothering people elsewhere. Do you have any difficulty in deciding where we draw the line—in other words, how much stream mileage do we give up? I know the situation in Wisconsin and it is becoming a problem; somehere we have to decide, as resource people, to maintain not only the warm-water fisheries but trout streams as well.

MR. DAY: I would not know how to answer your question. In Pennsylvania we spend about half of our income for warm-water fisheries and about half for trout fisheries, but most of these projects, the 13 we surveyed and in which we hope to share, are not on trout waters.

MR. RICHARD STROUD (Sport Fishing Institute): Mr. Day, you mentioned that the average cost would be $1,700 per surface acre, I believe. It is not clear to me whether this would include the cost of the land or whether this is exclusive of the land.

MR. DAY: This includes everything—land and development.

VICE CHAIRMAN DIEM: I would like to put a question to Mr. Day. We have had comments with regard to the East. What sort of a program do the states in the West, under Public Law 566, get into with regard to prior appropriation and also arid climatic conditions? Would you care to comment on this?

MR. DAY: The problems, of course, would be different. We are blessed, as I say, with an abundance of water but I think the principle in working through this local approach with P. L. 566 is very sound because it does get the local communities in. It gets local support instead of a Federal agency or a state attempting to do it all by itself. I think the advantages under this approach in P. L. 566 are many. However, the situation of building lakes in an arid country is far different than back in Pennsylvania.

MR. STEWART (North Dakota): This is not a question but a statement in regard to our feeling with regard to P. L. 566.

We are engaged in about 21 small watershed programs in North Dakota, either in the planning or the construction stage. We have found, especially in the eastern half of the state, in the glaciated area that is our prime waterfowl producing area, that many of these projects result in a net loss to wildlife and primarily to waterfowl because they actually become glorified drainage projects and create very little good fishing waters and, in the process, we also lose a lot of natural wetland.

In addition, it opens up for the private landowner to go in and drain water that he could not drain unless channelization was done by the public agencies.

EMIGRATION OF DROUGHT-DISPLACED DUCKS TO THE ARCTIC

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When the prairie pothole region is periodically seared by drought, what happens to the ducks which ordinarily use this area for nesting? How far will they travel to find suitable conditions and what is their reproductive success in the new environment?

These questions are of primary concern both in immediate and in long-range management plans. Current regulations should reflect reproductive success throughout the range of all species, and particularly the most vulnerable. For the future, acquisition and/or safeguarding of habitat should be emphasized on the very important periphery of the breeding range as well as on the prairies.

Progress has been made during the most recent drought in the plains states and Canadian prairie provinces to determine the emigration pattern of drought-displaced ducks. This paper is based upon data from aerial surveys in general and from specific ground studies in east-central Alaska, the terminus for several species of displaced prairie ducks. The evidence from aerial surveys is massive and circumstantial. That from the ground studies is a collection of minutiae corroborating the aerial.

MASSIVE EVIDENCE OF NORTHWARD MOVEMENT

For purposes of illustration, only the dabbling ducks will be considered in this instance. They are conveniently grouped in the summary reports and are more nearly representative of the prairies than the divers. Although canvasback and redhead are largely prairie oriented, to include the entire group of diving ducks would throw the analogy out of perspective. The northern breeding population is weighted heavily with scaup and scoter and to a lesser extent with goldeneye and bufflehead, none of which would be affected greatly by adverse conditions on the prairies.

The cumulative aerial survey data show an inverse relationship between duck populations on the southern prairies and in the northern habitat during periods of duress in the former (Crissey, 1961). As prairie potholes disappear and their associated waterfowl population diminishes, the duck population expands in the north. When the prairie becomes re-watered, it absorbs ducks at the expense of the north. These population shifts move rather consistently in the same

[1]Currently stationed in Korea with the U. S. Army Medical Corps. In the absence of the authors this paper was read by Mr. Sigurd Olson, U. S. Forest Service, Alaska.

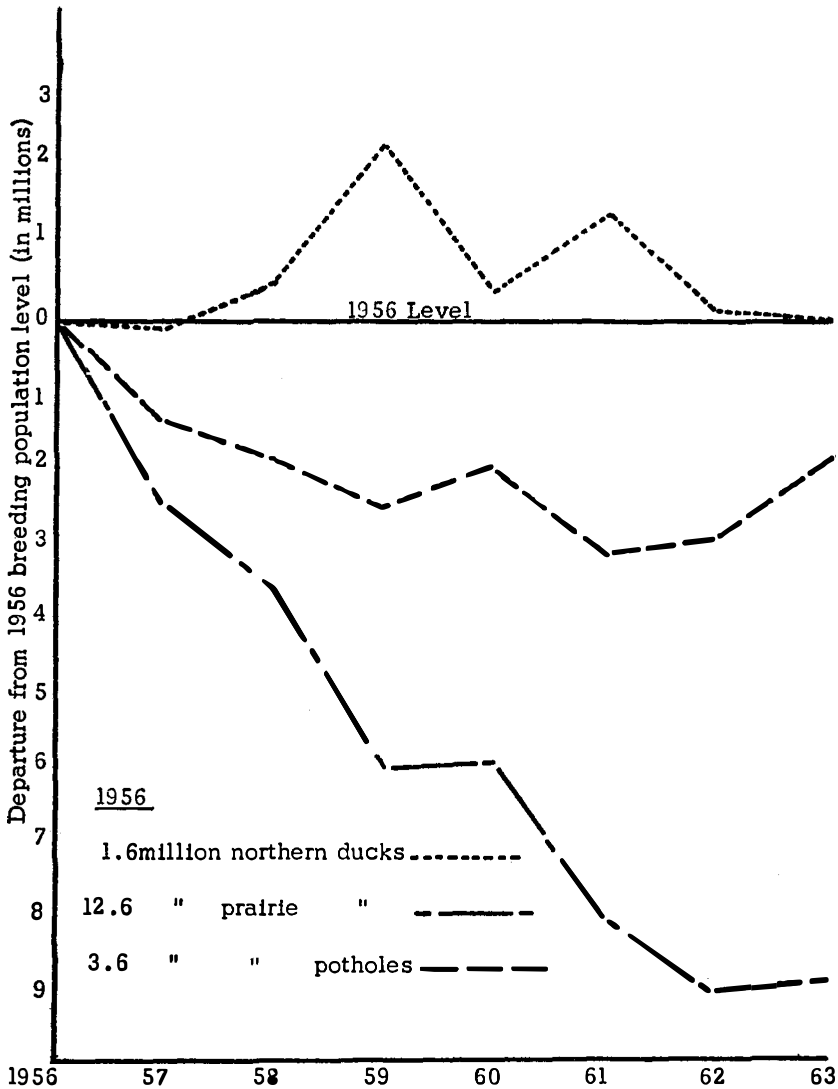

Figure 1. Inverse relationship of dabbling duck breeding population between prairie and northern habitat.

direction, but not in the same magnitude, and only for a limited number of years (Fig. 1). The prairie pothole dabbling duck breeding population index dropped from a high of 12.6 million birds in 1956 to 6.5 million in 1959, a loss of 6 million. During the same period, the dabbler index in northern Alberta, NWT and Alaska climbed from 1.6 million to 3.9 million, a gain of only 2.3 million.

A temporary respite in the prairie drought reversed the downward trend there slightly in 1960 where a breeding population index of 6.6 million dabbling ducks was calculated, up 0.1 million from the previous year. The northern index in 1960 decreased from 3.8 to 1.9 million dabblers, a loss far greater than the increase in the south. The drought intensified in 1961 with a further decrease of 2.0 million in the prairie index. There was a concurrent increase in the north but of only 1.1 million. In 1962, the prairie population lost another 1.1 million dabblers. The inversion between north and south had apparently run its course by now, however, because the northern habitat also lost 1.2 million dabblers, returning that population almost to its 1956 level. The northern population remained static in 1963 when the downward trend on the prairies was reversed with an increase in surface water for the second consecutive year. Whether or not the prairie population rebuilds explosively to its 1955-1956 peak, there is no reason to believe that it will do so at the further expense of its reservoir area in the north.

When drought forces ducks from the prairies many of them probably go no farther north than necessary to find suitable unoccupied habitat. The late-comers keep pushing north and west and some terminate in east-central Alaska. When the mass movement is viewed through some of its component parts the evidence looks thus. The basic population index on the 1,625 square-mile Athabaska Delta was 84,000 ducks (all species) in 1955, a year of abundant surface water on the prairies. In the drought year of 1961 the population index for the same area peaked at 250,000 ducks.

On the Slave River parklands, 7,500 square miles in extent and some 200 miles farther north, the change between 1955 and 1961 was an increase from 40,000 to 230,000 ducks. Across the Continental Divide lies the Old Crow Flats near the confluence of the Old Crow and Porcupine Rivers. The population index in this mountain-rimmed valley of 2,000 square miles increased from a base of 77,000 ducks to a high of 170,000 in 1961 (Smith, et al., 1964). In approximately 11,000 square miles of habitat in eastern Alaska the population index increased from 200,000 to 320,000 during the same period (Fig. 2).

DETAILED EVIDENCE OF PRAIRIE DUCKS IN ALASKA

Production studies and banding have been conducted near Ft. Yukon in eastern Alaska from 1953 through 1956 and from 1960 to date. A similar project has been in progress near Tetlin on the

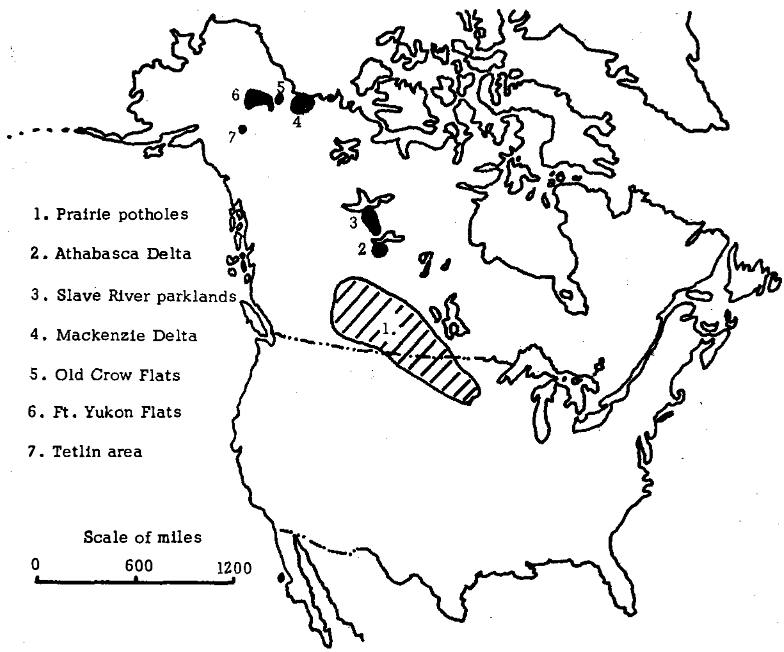

Fig. 2. Area of reference.

upper Tanana River since 1957. During these studies, blue-winged teal, redhead, ruddy ducks, ring-necked ducks, canvasback and shovelers were recorded either for the first time or in much greater abundance than formerly (Hansen, 1960), but not until after the onset of the current drought in the prairies. The species—new to Alaska—reached their peak abundance in 1959 and 1960. They have decreased steadily in the three subsequent years. Canvasback are common summer residents in eastern Alaska every year, but in 1959 and 1960 they were observed regularly along the Bering Sea coast as well. In addition to the regular breeding population in the upper Yukon and Tanana valleys, large rafts of idle canvasback were observed. The shoveler is also common in the eastern part of the state, but in 1959 they were observed in unprecedented numbers and large rafts were present in an idle status. Shovelers declined in abundance in subsequent years, but not in proportion to the decline in number of broods counted in Tetlin.

During the eastern Alaska banding operations, several species of ducks banded elsewhere were caught. In addition to banded birds recovered in traps, many out-of-state bands have been recovered from hunting activities. From an analysis of all these band recoveries, some appear to be useful in proving the existence in Alaska of drought-displaced ducks and others are of no value whatever. Pintail and widgeon fall into the latter category. Of 33 Alaska recoveries of pintails banded since 1948 in the prairie drought area, 16 were taken through 1957 (years of abundant water) and 17 were taken from 1958-1962 (years of drought). Neither sex nor age seems to have any bearing on the pintail's erratic pattern of dispersion. The pattern of widgeon recoveries is somewhat less erratic than pintails, but is not conclusive.

In contrast, five mallards banded as locals on the Canadian prairies have been recovered in Alaska, one in 1957 and the remaining four from 1959-1962. In addition, two adult prairie mallards were recovered in the latter period. This is interesting in light of the distribution of mallards banded in Alaska. Of 384 banded from 1948-1959, there have been 49 recoveries, all in the Pacific Northwest or enroute down the coast of Alaska. From 1959-1962, 100 mallards were banded with 14 recoveries, three from the Central Flyway, one from Utah and 10 from the Pacific Coast. There were four direct recoveries from 64 redheads banded at Tetlin in 1959; one each from Saskatchewan, Wisconsin, Nebraska and Texas. Additionally, there was one second-recovery from southern Alberta and one in 1963

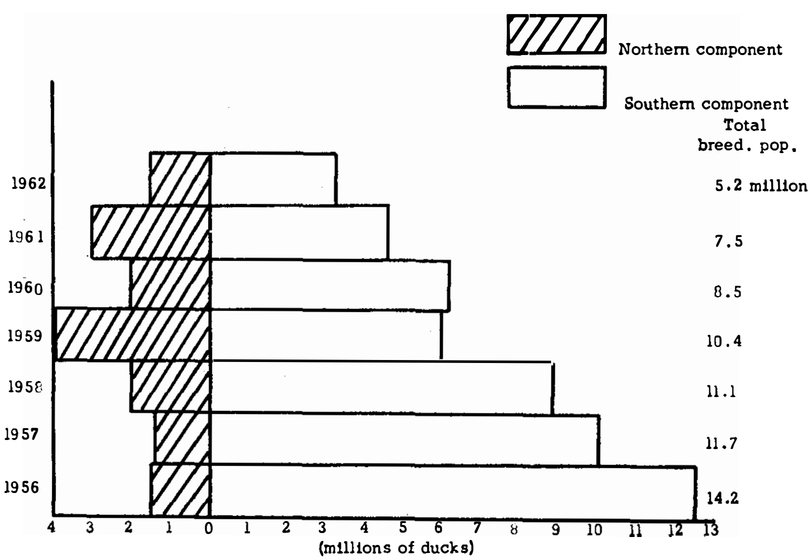

Figure 3. Dabbling duck breeding population index as derived from aerial surveys on prairies, NWT and Alaska.

from South Dakota. Green-winged teal and lesser scaup banded on the prairies have also been retrapped in subsequent years in eastern Alaska.

REPRODUCTIVE SUCCESS OF DISPLACED DUCKS

The stable northern habitat not only serves as a reservoir for drought-displaced ducks from the capricious prairies, but some of them will nest successfully after having extended their migration far beyond their home territory. Prior to 1959 there was only one record of blue-winged teal nesting successfully in Alaska (Kessel, 1955). Twelve broods were counted in the Tetlin area in 1959, three the following summer, four in 1961, and none since. Three redhead broods were observed in 1959, six in 1960 and none since. These are the only redhead nesting records from Alaska. One ruddy duck brood and one ring-necked duck brood were also recorded in 1959 with none observed since. With the exception of ruddy ducks, all these species have either been observed regularly or trapped in considerable numbers since 1962 when broods were no longer observed or at least in greatly reduced numbers (Table 1).

The relatively low production of these immigrant ducks is not due to small broods, but rather it seems to be a lack of effort from the outset on the part of most individuals. The average size of Class I and II broods at Tetlin from 1958 to 1961 was 7.2 for 19 blue-winged teal, 7.9 for 41 shoveler, 6.8 for 107 canvasback and 4.6 for 7 redhead broods. These compare well with broods in the prairie habitat under optimum conditions. A stronger nesting effort seems to be made in the first year or two these ducks arrive in the north than in subsequent years. This is based on the observation that the number of broods counted among the key species (redhead, blue-winged teal, shoveler) decreases at a faster rate than the total number of adults observed in the same area. Thus, no redhead nor blue-winged teal broods were observed in either 1962 or 1963 although adults of both species were still recorded regularly, though in smaller numbers than in the previous years. During 1962 and 1963, respectively, 24 and 18 flightless adult redheads were banded near Ft. Yukon. Teal were not taken because there was no early season banding when they would have been flightless.

TABLE 1. BROODS OF KEY IMMIGRANT SPECIES COUNTED AT TETLIN

Species	1958	1959	1960	1961	1962	1963
Shoveler	5	24	7	5	1	0
B. W. Teal	0	12	3	4	0	0
Redhead	0	3	6	0	0	0
Canvasback	22	24	18	18	18	14
Ruddy	0	1	0	0	0	0

Many of these displaced ducks arrive quite late as far north and west as Alaska. In fact, we have observed a "second wave" arrive after many of the early migrants already started to nest. These would have been missed entirely in the northern aerial breeding population surveys and this omission could account, in part at least, for the differential between birds absent from the prairie and not counted elsewhere during the first year or two of the drought. It is possible that the late arrivals wander considerably enroute, dissipate their energies and have passed their physiological primeness before settling down. Whatever process, then, triggers a renesting effort in more southern latitudes has been lost by the time these birds have settled onto Arctic marshes.

Although some individuals can and will nest successfully under displaced circumstances, not enough of them do to maintain an abundance commensurate with that attained in their normal environment. This is apparent when the breeding population index of 14.2 million dabbling ducks in 1956 had dwindled to 5.2 million in 1962 even though the northern component remained at or above the 1956 level throughout the period. As various decimating factors caught up with the displaced prairie ducks, they died out of the population without having contributed sufficiently to maintain their original abundance. By then, however, the stable northern habitat may already have served one of its most important, recurrent functions. As Lynch (1963) pointed out, "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 (stable northern areas) . . . are the detonators that kick off these explosions when other conditions decree that it can happen."

Based upon our expanded knowledge of the country and greater field experience of the past few years, we are quite certain that the recent influx of displaced prairie ducks into Alaska is nothing new. A similar movement surely occurred during the drought of the 1930's and others of like magnitude back through history and would already be a matter of written record if a naturalist had been in the field to observe the event.

Studies in the north should be accelerated generally so we may better determine what the basic waterfowl population structure is and how it contributes to the continental supply from year to normal year. Knowledge of weather cycles on the prairies may be progressing to the extent that they can be forecast with reasonable accuracy within the foreseeable future. Toward this end the northern studies should also be oriented to a better understanding of the factors affecting production among drought-displaced ducks when they are super-imposed upon a stable population already in residence.

The future of duck hunting may very well hinge on what is now the peripheral habitat beyond the "heartland" of production. The importance of this vast area should be clearly recognized and fully understood. As civilization and its attendant industrialization move northward at an accelerating pace, the "progress" they engender will pose a threat not only to the pristine condition of many of these areas but to their very existence. The best defense against destructive aspects of these developments should be a well-informed public standing firmly behind dedicated administrators.

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DISCUSSION

VICE CHAIRMAN DIEM: Mr. Olson has informed me that while he is not one of the authors of this paper, he would be glad to attempt fielding questions from the floor.

Mr. Olson, I wonder if you might anwser a question in regard to a comment Dr. Gabrielson made this morning with respect to the Rampart Dam. Obviously, this northward movement or displacement would involve much of the area under this proposal. How many areas, if any, are there north and west of this particular central Alaskan breeding range?

MR. OLSON: Actually, there are not many areas north and west. If you go north of the Brooks Range, for instance, the area up there is so infertile that the breeding ground does not produce much in the way of waterfowl. This would not be a good alternate area for ducks to go. The same is true further westward. I am speaking of north and westward. There just isn't much farther they can go, I don't believe.

MR. WALTER CRISSEY (Maryland): I think that this northern habitat that was talked of is extremely important and it can be further broken down into about six areas that are particularly important. These are a series of either river flats or river deltas in the north country that are highly productive.

As Sig mentioned, the northern habitat is vast, but the productive portion of the northern habitat, except for geese, is rather restricted. It is important, I believe, that this be recognized because there is a preservation problem involved.

The Grand Rapids Dam of Saskatchewan is already an intake area. The Dam is being built. The Yukon flats are also being taken under consideration for destruction.

Another important factor is that many of these deltas are productive because of periodic flooding. Relative to the Rampart Dam, there will be no more floods on the Yukon if that dam is built and so production in that area will stand a chance of going by the board.

MR. CHARLES YOCOM (California): I had the pleasure of seeing the Yukon flats and I would like to say that the Yukon flats themselves constitute an area the size of one that would be created by, say, blocking the Golden Gate Bridge and creating a vast waterfowl production area out of both of those valleys. That is the size of that one area that was mentioned.

Further, I think the problem is a little under-related because we do not know too much about it. Of course, we are learning more about it all the time.

VICE CHAIRMAN DIEM: There appears to be a question raised here which I believe is fundamental to some of our waterfowl research, and this is the rather disturbing comment in the decline of waterfowl production over the three-year period. To me, while one of these possibilities was raised by the authors of this paper, there are likewise some rather interesting possibilties on the other side of the ledger. I am not discounting the aspect of other considerations but it would seem to me that in view of the very excellent paper by Hanson of Illinois on the stress study of geese, that we here have a program of research that we have not investigated enough and that is—what effect does the environment have on the waterfowl when they are displaced from a rather southern latitude to a northernly latitude or, possibly, some other environmental influence that is indicative of conditions prevailing in that partcular area and which they did not encounter in the south? It seems to me a very odd situation that production should show such a steady and continuous decline over the three-year period.

MR. YOCOM (California): I may be in error but I believe that the author had in mind the ones to be replaced from the prairies, and I don't think he had in mind those that normally nest there. Am I correct? That is something that is very fundamental to this and I think you should realize that this is a very important aspect to it.

MR. OLSON: If I may make a comment on that I would like to say I believe that the author is referring to the ducks, the emigrant ducks so to speak, when he says that there seems to be lack of effort and that the reproductive success has gone down in three years. He was trying to point this out on the basis of banded birds they had recovered. Of course, I have no real good reason as to why this should happen. I think it is a phase of research that should be looked into and answered if possible because it is a big unknown. I think the number of ducks that could be involved presents an important question.

RADAR STUDIES OF WATERFOWL MIGRATION

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Illinois Natural History Survey, Havana, Illinois

Visual observations and band recoveries have long been used to chart the movements of waterfowl. To these two useful techniques, a third has recently been added, radar. Compared with other methods, radar has certain advantages and disadvantages for the study of waterfowl migration. For example, radar used in this study recorded bird targets at distances ranging up to 50 nautical miles, depending upon transmitted power, wave length, pulse width, beam characteristics, receiver sensitivity, and target density. Radar also recorded bird targets at night as readily as during daylight hours, and clouds were no barrier when their water content was low. However, precipitation and clouds heavily laden with water reflected enough energy to obscure bird targets on the radarscope. Ground targets also interferred with the reception of bird targets. On the other hand, visual observations are confined to daylight hours and are restricted by clouds, haze, and distance. Because most waterfowl migration is nocturnal, much of it passes unnoticed. Even during daytime, migrating waterfowl may pass undetected because of their high altitude. However, marked population changes can be used as an indication of migration, and often waterfowl can be seen departing at sunset and arriving at daybreak.

Time is a critical factor in radar observations of migration, as in visual sightings, but, with few exceptions, has no critical relationship to band recovery data because of the unknown interval between the arrival of a banded bird and its recovery. Also, recovery of banded waterfowl is largely restricted to hunting habitats and to hunting seasons, thereby limiting the collection and interpretation of data.

Visual observations and banding data both provide information on particular species, for species identification is the rule rather than the exception. On the other hand, radar observations shed little light on species composition. On the basis of flight speed and sometimes, target size, it is possible to distinguish waterfowl targets from passerine targets. It is frequently possible to distinguish between targets of ducks and geese.

We began using radar in the spring of 1960 to study the migration of birds in Illinois. Two stations were employed, one at Champaign and the other at Havana, Illinois. The region of surveillance was increased in the ensuing years, first by means of a mobile radar unit, and second by securing the cooperation of many radar stations operated by the U. S. Weather Bureau.

This report covers some of the physical aspects of waterfowl migration, obtained from radar surveillance during November 1962. Three stations of the U. S. Weather Bureau (Kansas City and St. Louis, Missouri; and Des Moines, Iowa) and our own radar station at Havana, Illinois, provided the data in this paper.

ACKNOWLEDGMENTS

The National Science Foundation (Grant 24265) and the U. S. Weather Bureau, cooperating with the Illinois Natural History Survey, made this study possible, I owe a deep debt of gratitude to the radar meteorologists at the Kansas City, St. Louis, and Des Moines weather stations for their diligence in sampling bird migration when weather conditions permitted. I especially desire to acknowledge the administrative support of the following Weather Bureau officials: Mr. Hal Foster at Kansas City, Mr. George Brancato at St. Louis, Mr. C. E. Lamoureux at Des Moines, and Mr. A. K. Showalter and Mr. Stuart Bigler in the central office at Washington, D. C. Acknowledgement is made to Dr. G. C. Sanderson, Dr. R. R. Graber, and Mrs. H. C. Schultz for editorial assistance.

METHODS AND MATERIALS

The U. S. Weather Bureau radar utilized in this study is designated as WSR-57. It has a wave length of 10 centimeters, a power output of 500 kilowatts, and a pencil beam of 2.2°. Of the two pulse widths available, 1 and 4 microseconds, the 4-microsecond pulse width proved superior for bird detection. WSR-57 radar can be operated at ranges from 25 to 250 miles, but for bird detection the 25-mile range proved most fruitful. Nevertheless, waterfowl targets were occasionally sufficiently dense to give echo returns out to 50 nautical miles.

The Havana radar is an aircraft type, designated APS-42A. It has a 3-centimeter wave length, a power output of 5 kilowatts, and a 3° pencil beam. The maximum range for waterfowl targets on this radar was about 5 nautical miles.

The beam of the WSR-57 radar was usually inclined 4° from the radar horizon to reach 10,000 feet altitude at 25 nautical miles. The APS-42A beam was inclined at 30° from the radar horizon during the period covered by this study. This provided a cone of radar energy sufficiently strong to record echoes from birds passing through it, regardless of altitude.

A permanent record of bird targets appearing on the radarscope was obtained from time-lapse photographs. One 5- to 10-minute, time-lapse photograph was made on the WSR-57 radarscope each hour

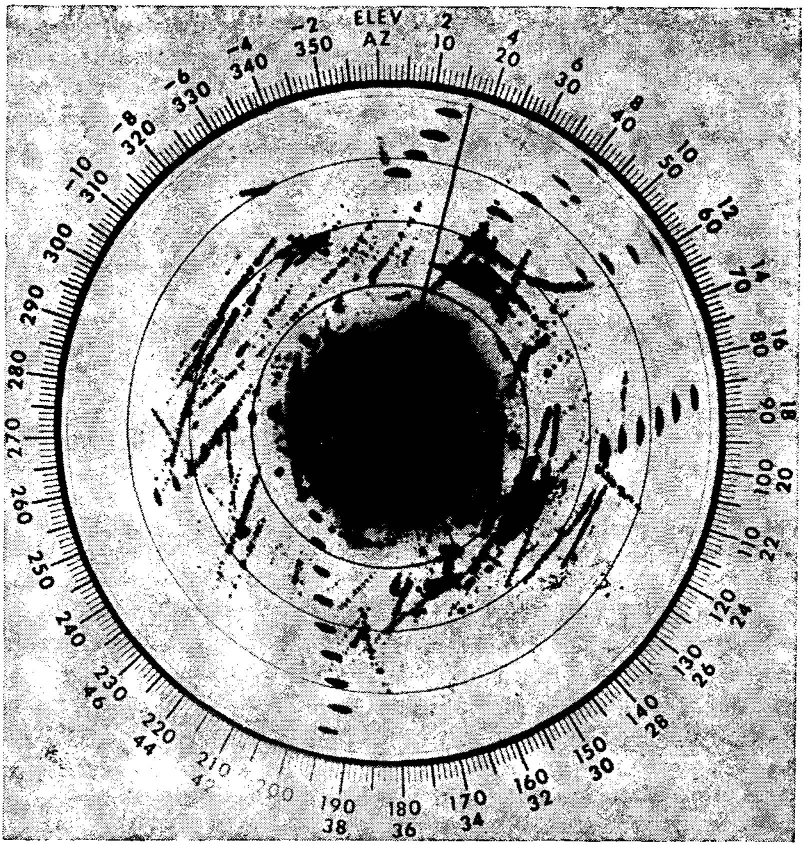

Figure 1. A photograph of the radarscope at St. Louis, November, 1962.

between sunset and sunrise (Figure 1). Two-minute, time-lapse photographs of the APS-42A radarscope were made continually during the night.

The antenna of the WSR-57 revolved three times per minute, but the camera recorded echoes on the radarscope only from every other revolution. The APS-42A antenna revolved 10 times per minute, and the camera recorded echoes from every revolution.

Time-lapse photographs recorded multiple echoes of the same target, as each recorded scan of the antenna placed the target in a different position on the scope. A series of recorded echoes of the same target produced a track which showed the direction of flight and, sometimes, the speed of flight. An enumeration of flight tracks by hours and days provided information on the temporal and chronological magnitude of migration.

Weather Bureau radars at Des Moines and St. Louis were operated on 25-mile ranges. At Kansas City, ground return extended out 25 miles on the radarscope, necessitating the use of the 50-mile range. On such long-range surveillance, waterfowl targets had to be unusually dense for sufficient energy to be returned to form echoes. Thus, only large movements of waterfowl were recorded at Kansas City.

Because of the limited range of the APS-42A, it is important to note its location. It was located 2 miles east of the Illinois River and 5 miles south of the Chautauqua National Wildlife Refuge; hence, waterfowl leaving the Illinois River valley were much more likely to pass within its range than waterfowl arriving from the north or northwest.

Further information evaluating the APS radar for bird-migration surveillance can be found in papers by Graber and Hassler (1962); Hassler *et al.* (1963); and Bellrose and Graber (1963).

Visual records of duck flights were obtained each day by noting departures from the Illinois River valley between sunset and dark, by noting arrivals of flocks after daybreak, and by observing changes in populations. A continuing build-up of waterfowl populations throughout the fall in the Illinois River valley made it easier to detect waterfowl arrivals than departures.

CHRONOLOGY OF MIGRATION

The chronology of waterfowl migration during November, 1962, in three of the four areas under radar surveillance (Figure 2), revealed some interesting differences resulting from geography. Des Moines is the center of a region devoid of important waterfowl habitat. Therefore, waterfowl tracks recorded by radar at Des Moines were samples of an extensive migration, mostly from areas in the Great Plains, to the Mississippi and Illinois River valleys. At Havana and St. Louis, most, but not all, of the waterfowl targets recorded by radar were apparently departing from the Illinois and Mississippi River valleys, respectively.

The difference in time between arrival of ducks into the Mississippi and Illinois River valleys and their departure was shown by differences in magnitude of nightly migration at Des Moines, Havana, and St. Louis. For example, a large passage of ducks appeared on the Des Moines radar the night of November 6-7 (Figure 2). Yet, bird targets were few at Havana the same night, and were only moderately numerous at St. Louis. The following night, duck targets were

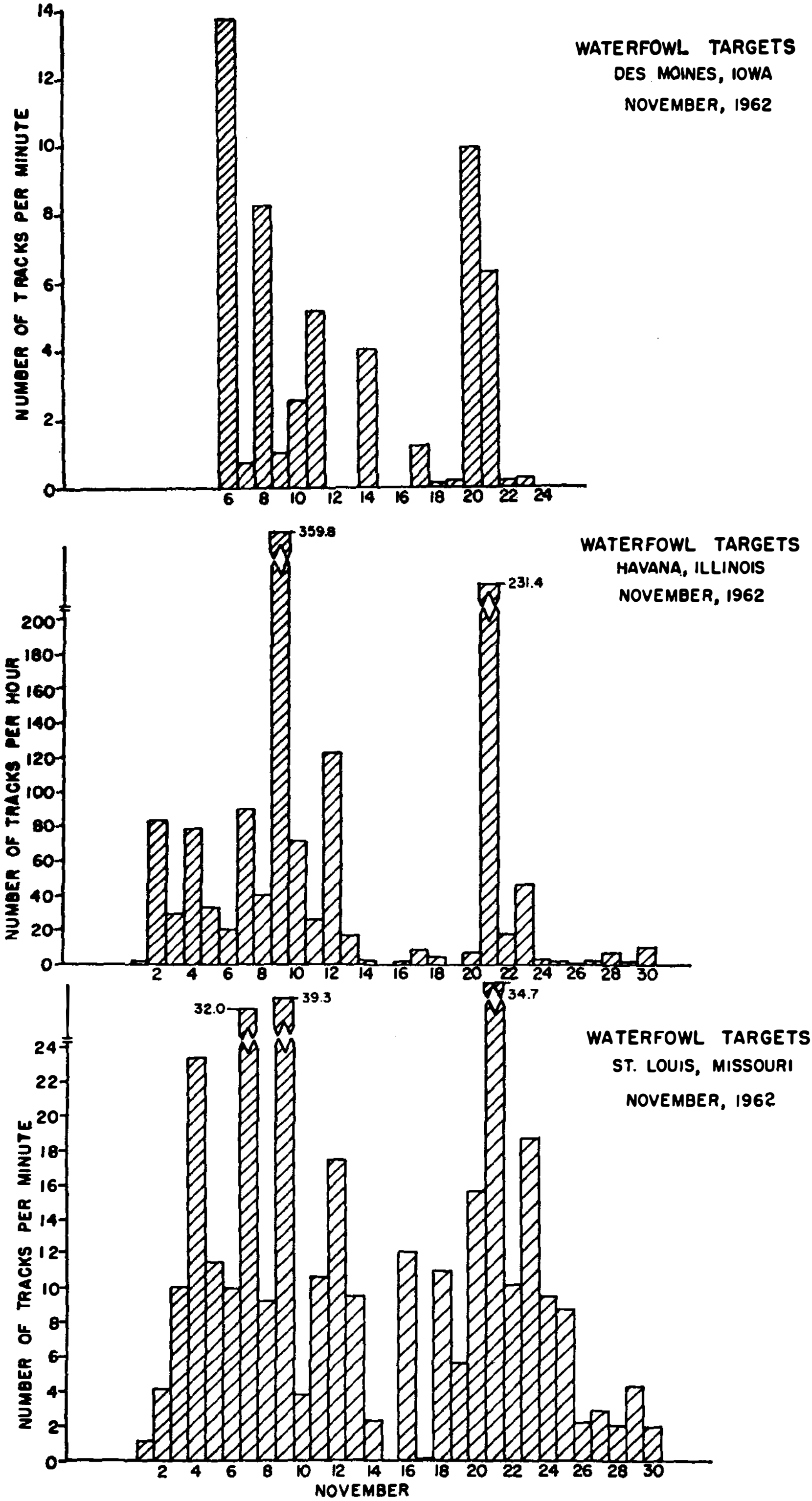

Figure 2. The chronology of radar waterfowl tragets at Des Moines, Havana, and St. Louis during November 1962. Blank spaces indicate no records.

few at Des Moines, moderately numerous at Havana, and very numerous at St. Louis.

On the night of November 8-9, a large number of duck targets were tracked by the Des Moines radar, but numbers were small at Havana and only moderate at St. Louis. The following night, when waterfowl targets were few in number at Des Moines, they were numerous at Havana and St. Louis.

The night of November 20-21, large numbers of duck targets were recorded at Des Moines, but only small numbers were recorded at Havana and moderately large numbers at St. Louis. The following night, November 21-22, very large numbers of duck targets were detected by Havana and St. Louis radars. Large numbers of targets, apparently from the same flight, also appeared at Des Moines that night (Nov. 21-22); and although large numbers showed up on several subsequent nights at St. Louis, only a small number was recorded at Havana. In other words, the duck flight from the plains, which passed Des Moines on a given night, largely stopped in the Mississippi and Illinois River valleys the same night. The weather conditions that had triggered the movement of ducks from the Dakotas, Manitoba, and Saskatchewan, then moved down to trigger a departure, a night later, from the Mississippi and Illinois River valleys. Many of the ducks leaving these valleys had just arrived the night before; others had been there for several days or several weeks.

Relatively more ducks appeared in migration at St. Louis than at Havana on nights when major flights passed Des Moines. This strongly suggests that a small segment of these flights continued in migration, not stopping in the Mississippi River valley above St. Louis. A greater proportion of migrants apparently alighted in the Illinois River valley than alighted in the Mississippi River valley, because of the relatively small number recorded by the radar south of Havana on those nights when major flights passed Des Moines.

Kansas City radar showed large movements of waterfowl during the nights of November 7-8, 10-11, 18-19, 19-20, 20-21, 21-22, and 23-24. Each of these first four flights occurred a night earlier at Kansas City than at Des Moines. The duck flights at Kansas City which began on November 18 and ended on November 24 represented a tremendous exodus from the Great Plains. At this time, apparently, many more ducks moved south along the western border of the Mississippi Flyway than moved south farther east.

The earlier appearance of migrating ducks at Kansas City than at Des Moines probably indicates that the flights originated from different regions. It appears evident that ducks moving along the western border of the Mississippi Flyway departed from more western areas in the Great Plains than did those migrating into the central part of the flyway. Weather patterns which trigger migration move either from west to east or northwest to southeast. Thus, weather influences waterfowl in the western and/or northwest plains before it influences those inhabiting areas to the east and/or southeast.

Radar and visual observations, indicating the chronology of waterfowl movements in the Illinois River valley, were in fairly close agreement. Havana radar recorded numerous departures of waterfowl, a few of which escaped visual detection. For example, the exceptionally large departure on the night of November 9-10 was missed visually.

A sizable arrival of waterfowl, indicated by visual sighting at Havana, was undetected by radar at Des Moines on the night of November 13-14, because no radar records were available for this night. Because of heavy rain clouds, Havana radar failed to detect departures of ducks on the nights of November 14-15 and 15-16. However, large numbers of ducks were seen leaving the river valley at dusk.

Visual observations indicated duck flights arriving in the Illinois River valley on the nights of November 2, 3, 4, 5, 7, 8, 12, 13, 17, 18, and 23. Ducks were observed departing on the nights of November 4, 8, 14, 15, 21, 22, 28, and 29.

A combination of visual and radar observations indicated that departures of ducks from the Illinois River valley sometimes occurred on the same nights new birds arrived. However, in most cases each large departure took place during the night following the arrival of a large flight.

AREA FLIGHT DIRECTION

The flight tracks of migrating waterfowl, as revealed by radar, showed considerable variation in direction from night to night. However, a compilation of the mean nightly flight tracks showed important area differences in direction of migration (Figure 2).

At Des Moines, in November, 1962, most waterfowl migrated south-southeast, with mean flight tracks ranging between 145° and 165°. The next most significant direction of migration was directly south. A small segment of the migrants flew south-southwest; part, if not all, of these migrants were believed to be blue and snow geese (*Chen hyperborea*).

Although the Des Moines River, a moderate-sized stream, flows through Des Moines, there was no evidence that waterfowl utilized it as a landmark to guide their line of flight. There were as many migrants 10 to 20 miles east and west of this river as there were adjacent to it.

For 75 miles above Des Moines the river flows toward 157°. At Des Moines the river changes rather abruptly to a course of about 123°, which it follows for 150 miles to its confluence with the Mississippi River at Keokuk. The mean line of flight paralleled the axis of the Des Moines River valley above Des Moines, but the direction of migration did not change as the axis of the river valley changed below Des Moines. Thus, the direction of the river and the flight lines north of Des Moines appeared to be unrelated.

Most waterfowl migrants, recorded by the Weather Bureau radar at Kansas City, were flying a course between 165 and 175 (Figure 3). Migration surveillance was conducted with the radar set on a range of 50 nautical miles. At times, waterfowl were so dense that migrants were detected and tracked at distances of over 50 statute miles from the radar station. On these occasions, an east-west cross-section of the line of flight was obtained for slightly over 100 statute miles. In all this distance there was a remarkable uniformity in direction of flight.

Some waterfowl flights at Kansas City were distributed rather uniformly east and west of the Missouri River. Other flights were unevenly distributed in respect to their passage south, east and west of the river valley.

The Missouri River makes an abrupt bend from south-southeast to east at Kansas City. From Sioux City, Iowa, the Missouri follows a course of 160° for roughly 250 miles to Kansas City, where it turns to flow toward 95° for about 250 miles to St. Louis. In spite of this major change in the course of the Missouri River, there was no evidence from radar that waterfowl altered their line of flight from south-southeast to east in the area of Kansas City.

The mean migration direction of waterfowl (165°) approximated the 160° course of the Missouri River from Sioux City to Kansas City. However, because of similar directional flight up to 50 miles east and west of the river, and because the waterfowl did not turn to follow the river at Kansas City, we concluded that the close parallel between direction of migration and course of the river between Sioux City and Kansas City, was unrelated.

The bulk of the waterfowl recorded by the Havana radar in November, 1962, was migrating in directions between south and southwest (Figure 3). Those migrating between 175° and 195° were heading directly for the principal wintering grounds of most species of Illinois ducks. These were believed to be ducks which had previously

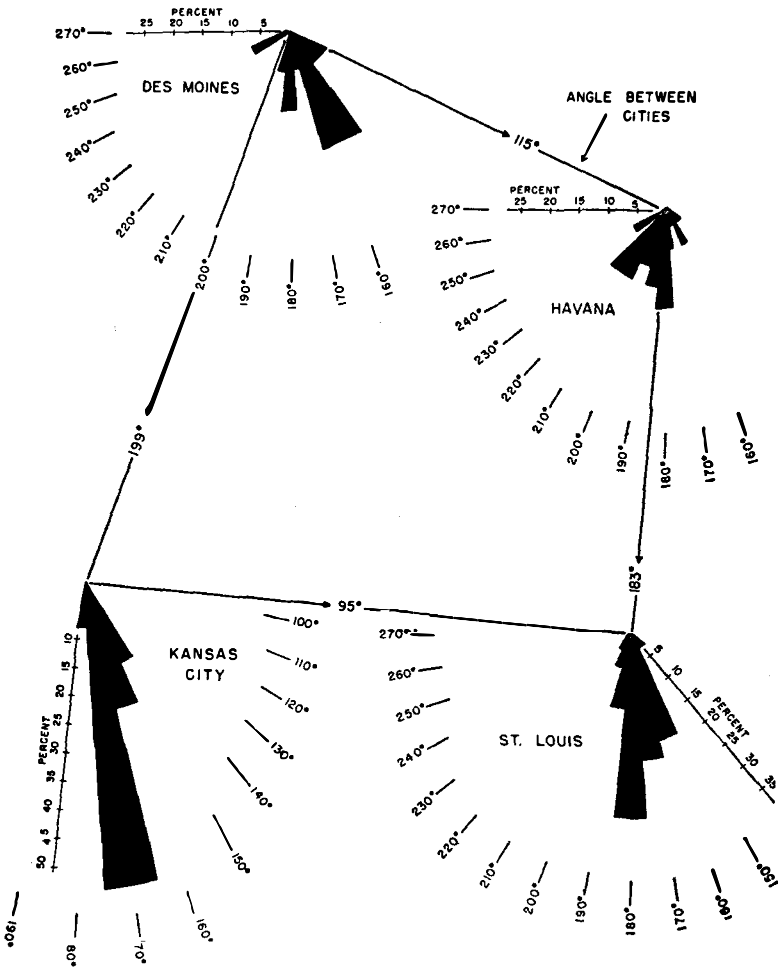

Figure 3. The flight directions as shown in percentage of total, taken by ducks during November 1962 at four radar stations in the Mississippi Flyway. Stations positioned on graph in bearing to each other.

arrived in the Illinois River valley and were recorded in migration soon after departure from river lakes north of the radar site.

The principal wintering grounds for mallards (*Anas platyrhynchos*) lie in Tennessee, Arkansas, Mississippi, and Louisiana, on a bearing between 180° and 195° from the Havana radar station. The principal wintering grounds for other Illinois ducks lie along the Gulf Coast of Louisiana, on a bearing between 175° and 195° from central Illinois. However, a proportion of the waterfowl targets on the Havana radar moved toward directions between 195° and 225°. These were thought to be ducks which had previously arrived at the Illinois River northeast of Havana, and, in resuming migration, paralleled the valley southwest for some distance before heading more directly south. The Illinois River valley for some 15 miles above and below Havana extends from 35° to 215°. Between Peoria and Meredosia, a distance of about 80 miles, the axis of the valley extends from 45° to 225°.

Waterfowl migrating past the St. Louis radar location flew largely toward directions between 155° and 185° (Figure 3). Those migrating with flight tracks between 155° and 175° were considered to be migrants still in transit from areas north of Iowa, possibly heading for important gathering areas in southern Illinois, Reelfoot Lake, Tennessee, or the Obion River swamps in Tennessee.

The large proportion of ducks passing directly south (175°-185°) and the smaller proportion which passed south-southwest (185°-205°) were believed to be birds which had previously arrived in the Illinois or Mississippi River valleys and were resuming migration. Upon resuming migration they altered direction, from that taken to reach the river valleys, in order to head directly for wintering grounds in eastern Arkansas or the coastal marshes of Louisiana.

TIME AND FLIGHT DIRECTION

An analysis of direction taken by waterfowl in relation to time of day was made to evaluate the influence of the Illinois River valley on migrants in transit and on those arriving or departing. It was assumed that ducks would most likely follow or parallel the Illinois River valley when departing in the evening and arriving in the early morning. At these times, the river valley would be most clearly visible to the migrants. Indeed, I often saw a portion of many departing flights move down the valley at sunset. In early morning, flocks of arriving ducks were observed moving down or paralleling the valley until their "home" lake was reached (Bellrose, 1957:9 and Bellrose and Sieh, 1960:37).

As mentioned previously, the Illinois River at Havana flows in directions between 215° and 225°. Therefore, flight directions in that sector might indicate that waterfowl utilized the river valley as a landmark and guide line. Ducks flying southeast or south would be leaving the river valley and flying over a prairie area of Illinois devoid of significant landmarks for 100 to 200 miles.

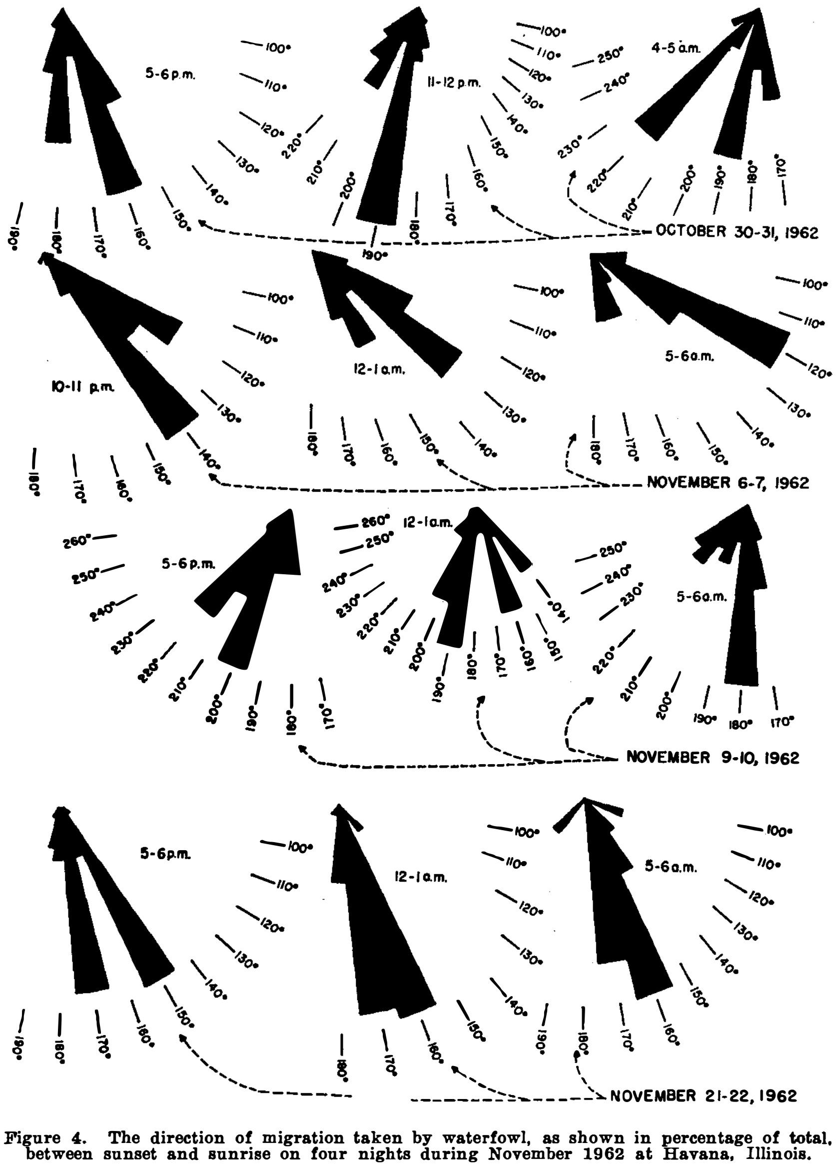

Figure 4. The direction of migration taken by waterfowl, as shown in percentage of total, between sunset and sunrise on four nights during November 1962 at Havana, Illinois.

Figure 4 shows the flight directions of waterfowl at Havana during evening, midnight, and dawn periods on four different nights. On only 2 of the 12 periods sampled (5-6 AM on October 31 and 5-6 PM on November 9) were there significant numbers of waterfowl migrating in directions paralleling the river valley. Those recorded from 4 to 5 AM on October 31 were probably arriving ducks; those recorded from 5 to 6 PM on November 9 were undoubtedly ducks departing from the river valley. It is obvious that the course of the river valley influenced only a small proportion, if any, of the departing waterfowl. Even though the ultimate course of the river is south, few migrating waterfowl utilized the proximate southwest course for even a few miles.

With the exception of 4 to 5 AM, October 31, the general flow of migration was similar throughout each night, although differing between nights. Because the general direction throughout the night was similar to that immediately after sunset, we believe that most targets represented ducks departing in migration. This is further evidence that arriving waterfowl alighted in the Illinois River valley before reaching the site of the Havana radar, slightly east and south of the Illinois River.

TEMPORAL DISTRIBUTION

The temporal distribution of radar waterfowl targets at Havana during November, 1962, is shown in Figure 5. Previous evidence indicated that most of these targets represent ducks departing in migration from the Illinois River valley. Ducks began leaving in numbers soon after sunset, and there was a sharp rise in the rate of departure from early evening until 8:30 or 9:30 PM. After 9:30 PM, the rate of departure declined, rapidly at first, and more slowly after midnight.

We were surprised by the protracted period of departure exhibited by so many waterfowl. From visual observations we had the impression that most ducks departed in migration soon after sunset.

DISCUSSION

Radar surveillance, visual observations, and band recoveries are complementary means of studying the migration of waterfowl. From radar studies conducted in the central region of the Mississippi Flyway in the fall of 1962, new knowledge was acquired concerning the migration of waterfowl.

Radar revealed that there were few discernible differences in waterfowl migration along the border between the Central and Mississippi flyways within 50 miles of Kansas City, Missouri. At times, the

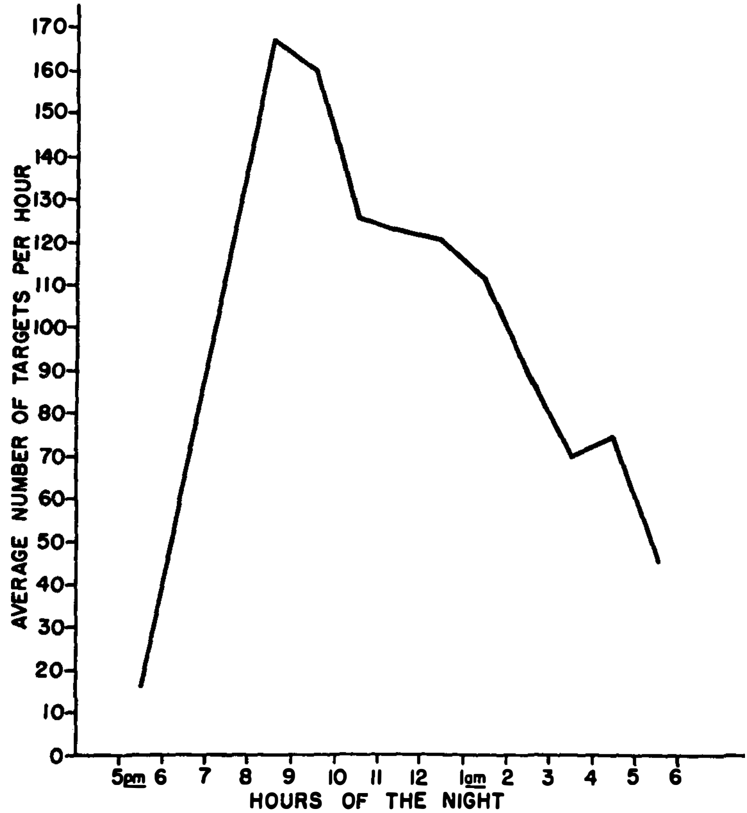

Figure 5. The temporal pattern of waterfowl targets as determined by radar studies, at Havana, Illinois, November, 1962.

bulk of migrating ducks shifted between the east side of the Central and the west side of the Mississippi Flyway.

Ducks migrating along the western border of the Mississippi Flyway generally began their flights sooner than those farther east. Moreover, their line of flight was only 5° to 15° east of south, whereas those migrating toward the Mississippi and Illinois River valleys flew 15° to 35° east of south.

The broad front of migrating ducks, moving southeastward across Iowa and northeastern Missouri, intercepted the Mississippi or Illinois River valleys. After alighting in one of these river valleys, most waterfowl changed their angle of flight when resuming migration. This change in flight direction from southeast to south or south-southwest involves many millions of ducks. The large number of waterfowl involved and the major change in flight direction make this a phenomenon of migration that is unknown, and probably unequaled elsewhere in the world.

As yet, we do not know whether waterfowl migrating at night must first alight in the Illinois or Mississippi River valleys in order to change their angle of flight, or whether this change can be effected visually at night. We have watched from an airplane as a tremendous diurnal flight of ducks arrived at the Mississippi River valley (Bellrose and Sieh, 1960:33-34). After reaching the valley, most migrating ducks turned from southeast to south. Whether darkness prevents waterfowl from utilizing landscape cues to make this significant change in direction is conjectural. Radar revealed that waterfowl migrating at night did not alter their flight direction to conform to changes in the course of large rivers. Nocturnally migrating waterfowl, arriving from the northwest at the Mississippi River in the vicinity of St. Louis, did not appreciably alter flight direction to follow the river valley.

The 24-hour time lag between arrival of waterfowl in the Illinois River valley, from the northwest, and their departure south or south-southwest suggests that waterfowl need to obtain landscape cues during the day, before undertaking this major change in direction of migration.

SUMMARY

1. Radar surveillance of waterfowl migration was conducted at Kansas City and St. Louis, Missouri; Des Moines, Iowa; and Havana, Illinois, during November 1962.

2. The chronology of waterfowl migration differed slightly among the four radar stations. Flights of ducks usually arrived one night earlier at Kansas City than at Des Moines, and those at Des Moines arrived one night earlier than those at Havana and St. Louis. The time lag in waterfowl passage between Des Moines and Havana-St. Louis was attributed to a large proportion alighting in the Mississippi or Illinois River valleys.

3. The direction of migration differed at the four stations. At Des Moines, waterfowl migrated in a southeasterly direction; at Kansas City, migrating waterfowl flew slightly east of south. Most waterfowl departing from the Mississippi and Illinois River valleys, changed their flight angle to south or southwest.

4. The majority of waterfowl migrating at night did not appear to be influenced in their course of flight by major river valleys.

5. At Havana, the general direction of flight remained similar throughout most nights. On occasion, there was evidence that some

waterfowl followed the Illinois River valley, especially late in the evening and early in the morning. Many ducks, however, flew away from the river valley at an angle.

6. Waterfowl began leaving the Illinois River valley shortly after sunset, and departures continued throughout most of the night.

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DISCUSSION

VICE CHAIRMAN DIEM: Thank you, Mr. Bellrose. I think you have given us the food for thought as evidence of the tremendous strides that we have seen taking place in some of this earlier work. I remember not too many years ago some studies along about this line conducted by other individuals, some studies as to cause and relationships.

MR. EARL ROSE (Iowa Conservation Department): Since Frank mentioned Des Moines as one of his key radar stations, I would like to comment briefly about that.

I am wondering, first of all, Frank, do you have any radar data taken during the goose migration and, if so, what does this data indicate?

My second question is, do you think that radar could be synchronized with sound recordings on goose migrations in order to get some concept of the magnitude of this in a localized area, especially in relation to the major migration groups of Canadian geese?

MR. BELLROSE: Sometimes it is difficult to determine duck tracks from goose tracks upon radar. Usually we can differentiate the two on the basis of altitude. Geese are flying several thousand feet higher than ducks and, further, geese move slower than ducks. Therefore, on the basis of night speed, we can differentiate geese far greater from duck targets and, furthermore, sometimes the goose flocks are so dense that they create a larger return in pulse width. I might add here that a pulse width is a microsecond or four microseconds as the case may be; a millionth of a second for our smaller radar and four millionths of a second for the Weather Bureau radar. A millionth of a second is a tenth of a mile, and so a flock have to be longer than a tenth of a mile or a series of them would have to be longer than a tenth of a mile in order to create a larger echo.

Therefore, the radar actually magnifies every echo that it picks up unless it is larger than the beam width or pulse width.

We have found that some geese are often flying at 10,000 feet and actually they create a little different occurrence in their tracks because of the wavy flight.

As to a tape recorder, that would certainly help. It would help to identify some of the species. I might say that we used a tape recorder before we got into radar but, unfortunately, with ducks, they seem to be very quiet at night because throughout the month of November, back in 1959, we picked up very few night calls of ducks. We would hear the rush of their wings quite often as the flock would pass over the area and this sound would be concentrated. Geese, of course, are quite noisey at night, and we did pick up calls of many geese.

The reason we abandoned the tape recording of nocturnal calls of birds is that it got to be too large an operation to handle and it required an experienced person to identify many of the nocturnal calls. In fact, even the most experienced person cannot identify all nocturnal bird calls and, consequently, this was more than we would do. We could farm out to housewives or students reading of the radar film, but in reading the tape of nocturnal bird calls, we had to do this ourselves and this got to be quite a chore. However, it would still be one way of separating the goose from the duck targets.

Somebody also asked about the frequency of radar operation. The small radar has a wave length of three centimeters from which the efficiency can be determined, and the large Weather Bureau radar operated on a ten centimeter basis—a wave length several times longer, which was still sufficient to give a good discreet echo.

THE USE OF AMMONIUM NITRATE FOR MARSH BLASTING

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U. S. Forest Service, Cass Lake, Minnesota;

JOHN BYELICH
Department of Conservation, Mio, Michigan

ROBERT RADTKE
U. S. Forest Service, Milwaukee, Wisconsin

Intensive efforts are being made throughout North America by public and private organizations to preserve or develop our remaining wetlands. The maintenance and restoration of numerous small, shallow potholes and marshes constitute a challenging problem in waterfowl management.

Extensive marsh areas supporting continuous stands of emergent vegetation are unproductive. Habitat for waterfowl can be improved by creating open water in the form of "potholes" or level ditches. Various methods have been used to create open water. Draglines and bulldozers are effective; however, wet soil conditions and poor access often limit the use of heavy equipment. Scott and Dever (1940) reported on the use of dynamite for removing emergent vegetation in a dense bulrush-cattail community in Iowa. Provost (1948) detailed blasting techniques using dynamite and indicated that blasting would benefit waterfowl where open water was lacking in the total habitat requirement of the area. Wildlife values in marshes are largely dependent upon a favorable balance or interspersion of cover and open water (Low, Scott, and Dever, 1941). Present cost of dynamite limits its widespread application for habitat improvement.

The use of a relatively new blasting agent, ammonium nitrate, has proven to be an effective and less expensive method of improving certain marsh areas. The Michigan Department of Conservation and the U. S. Forest Service cooperated in using ammonium nitrate for marsh blasting. The technique as applied in Michigan was used on extensive marsh areas containing continuous stands of emergent vegetation. On the Chippewa National Forest in Minnesota, ammonium nitrate was used to reclaim small woodland potholes. These are extremely important for waterfowl production, if open water is present (Evans and Black, 1956). These potholes provide seclusion for mated pairs to establish territories and carry on courtship activities. Although the hen and brood may utilize the pothole for a brief period, brooding usually takes place in an adjacent larger body of water located within one-half to one mile. Natural succession has reduced many potholes to unproductive wetlands supporting dense stands of sedges, grasses, and brush.

Draglines and bulldozers have been used on the Tamarac National Wildlife Refuge in Minnesota for reclaiming both extensive marshes and small woodland potholes. Mated pair counts have indicated over 90 percent use of these reclaimed wetlands (Hunt, 1963). The Wisconsin Conservation Department is currently conducting research to evaluate water areas created by both heavy equipment and blasting (Mathiak, 1963).

AMMONIUM NITRATE

Ammonium nitrate (AN), when mixed with a carbonaceous "carrier," such as fuel oil, and detonated with an explosive primer has proven to be an inexpensive and effective blasting agent.

Ammonium nitrate is a common commercial fertilizer.[1] The use of AN as a blasting agent has gained wide acceptance in the mining field. Low cost is one reason for its popularity—about one-fifth the cost of similar work using dynamite. Another factor is safety. Ammonium nitrate is not classed as an explosive, but as a "blasting agent" and is quite insensitive when compared to dynamite. Under normal conditions, AN cannot be detonated by means of a No. 8 test blasting cap.

For best results, uncoated prilled ammonium nitrate should be used. Many agricultural varieties of AN contain a coating of diatomaceous earth, which limits the fuel oil sensitizer from thoroughly saturating the AN prill. This results in an incomplete detonation characterized by low blast strength, and dense yellow-orange smoke during the blast. This smoke indicates a concentration of toxic oxides of nitrogen. An efficient blast produces a minor amount of white smoke. Several companies manufacture a variety of AN specifically designed for blasting, and also premixed with the fuel oil carrier.

[1]The principal forms of AN (solid) are prilled, granular, crystalline, and grained. The prilled form (passing 140 mesh U. S. Standard Sieve, and retained on 325 mesh; about No. 4 "shot" in size), mixed with fuel oil, is the most satisfactory for field-compounded blasting agents (Anonymous, 1963).

CARBONACEOUS CARRIER

For best results, No. 2 fuel oil is mixed with prilled ammonium nitrate at the rate of 5.4 to 6 percent by weight. A standard field mix is one gallon fuel oil per 100 pounds of AN. Mixing, and a minimum forty-five minutes' soaking time are recommended. However, when AN is prepared in the field, a common practice is to open the bag and pour in the correct amount of oil. When this procedure, lacking stirring, is used, the product (AN/FO) is greatly improved by a prolonged soaking period of at least 24 hours. This allows the prills to absorb the oil uniformly. Although mixing and soaking times are not critical, good field preparation is essential to the development of maximum usefulness of the product.

PRIMER

A dynamite primer, or specially prepared booster, is needed to initiate the detonation. A medium strength dynamite (50 or 60 percent) is recommended. A full one-half pound stick is recommended for 40 to 50 pound charges. One-half stick may be used for small quantities of AN. Unlike ditching dynamite, which may be detonated by the propagation method, each ammonium nitrate charge must contain a separate primer.

PREPARING THE CHARGE

The main disadvantage of ammonium nitrate is that it must be kept dry. When used under wet conditions, typical of most marsh areas, the AN can be sealed in waterproof polyethylene bags. These must be of sufficient strength (about 10 mil.) to prevent puncturing. Ammonium nitrate can be purchased in polyethylene sacks.

When simultaneous detonation of multiple charges is desired, detonating cord is recommended. A suitable length of detonating cord is attached to the dynamite primer in each AN/FO charge. The primer is inserted into the center of the prepared AN/FO mix, and the waterproof bag sealed with tape or cord. The detonating cord from each AN/FO charge is then connected to a "main line" of detonating cord (Figure 1). An electric detonator or blasting cap is attached to the detonating cord to initiate the blast.

Individual AN/FO charges could be connected with electric caps for simultaneous detonation. However, the normal distance between individual AN/FO charges (10-12 feet) is often greater than the lead wire length of standard electric detonating caps. Safety and convenience are two additional reasons for using detonating cord, since only one electric detonator is used. In addition, blasting cap and fuse may be employed with relative safety.

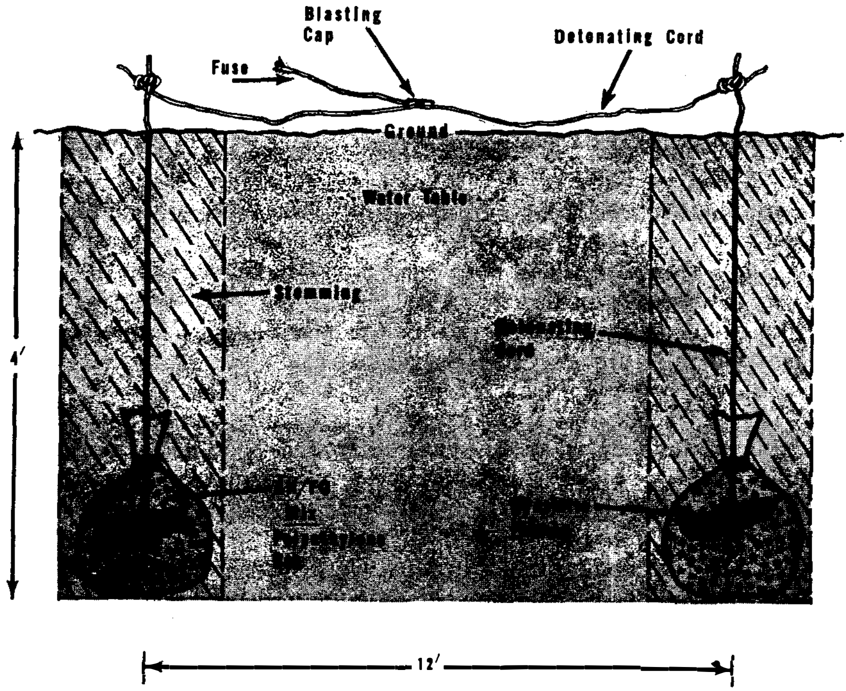

FIG. 1. Two 50 lb. of AM/FO with Detonating cord and dynamite primer. (Heavy clay soils, Chippewa National Forest, Minnesota)

PLACING THE CHARGE

The size of individual charges largely determines the depth of excavation. Charges will normally be placed three to five feet below the surface. Dirt is used as stemming to confine the blast and to keep the charge from floating. This is especially needed where water is present in the hole, as AN is lighter than water. When sealing the waterproof bag containing the AN/FO charge, remove as much air as possible. Detonating cord "leads" from individual AN/FO charges are securely tied to the "main line." Knots (clove hitch) should be tight, at right angles, and in close contact with the "main line" for a dependable explosion (Fig. 1).

DETONATION

Either a standard electric or a blasting cap with fuse is used to initiate the blast. When multiple charges are used, the cap is attached (taped with rubber or plastic electrician's tape) directly to the detonating cord. The action is as follows:

Detonator (electric, or cap and fuse) is exploded which sets off the deonating cord. The detonating cord simultaneously ignites all the dynamite primers, which then "trigger" the main AN/FO charges. This process occurs as one "blast."

A moderate to strong wind blowing away from the axis of the charge will help keep debris from falling back into the excavation. This is especially true for large-diameter holes.

RESULTS

Work done in Michigan by the Michigan Department of Conservation and the U. S. Forest Service, and in Minnesota by the U. S. Forest Service, indicates that this technique can be used to improve extensive marsh areas as well as for reclaiming small woodland potholes. Testing was done with various sizes and arrangement of charges. Typical results included:

In Minnesota good results were obtained in heavy clay soils from two 50-pound charges placed 12 feet apart. Charges were placed three to four feet deep. This resulted in a pothole 25 feet by 35 feet by seven feet deep. Total cost, including labor, was $11.00.

Six, 50-pound charges placed in two rows on 10-foot centers produced a hole six feet deep, 30 feet wide, and 40 feet long.

In another test two eight-pound charges in peat marsh soils (Michigan) created a pothole 14 feet by 19 feet by four feet deep. Total cost was $4.00.

One 50-pound charge in peat created a 25-foot diameter hole, seven feet deep. Total cost was $5.60. AN/FO costs one-fifth to one-third as much as similar work using dynamite.

The largest charge tested was 972-pound blast (three rows, twelve charges long, on 10-foot centers; each charge containing 27 pounds of AN/FO) to create a fishing pond 60 feet by 120 feet and eight to ten feet deep. Cost of materials was about $50.00. The explosive force of such a large charge of AN/FO has to be seen to be appreciated.

The average depth of the charges tested was three to four feet. Increasing the depth resulted in a deeper but narrower hole. Blasts at depths of two to three feet resulted in somewhat shallower and wider holes, particularly in heavy clay soils. Where the depth of the charge was less than two feet, the explosive force was dissipated upward, and poor results were obtained. Blasting efficiency varies widely by soil types. Testing is advised. Best results are obtained in peat marshes if mineral soil occurs three to four feet below the surface.

MILITARY CRATERING CHARGES

A mosquito abatement and waterfowl habitat improvement project, designed to determine the effectiveness of military cratering charges, was intitiated by the Parker River National Wildlife Refuge, Massachusetts, in March of 1963. Blasting was done in cooperation with the Army Corps of Engineers.

Military cratering charges contain 42 pounds of AN, and include a TNT booster. The charge is contained in a metal cylinder six inches in diameter and thirty inches long.

Single charges were judged to be the most efficient. Material cost per average crater (average diameter of 25 feet by four feet deep) was approximately $12.00 (Appel, 1963). This would compare with a cost of about $3.00 per 40-pound charge of AN/FO mix.

The Refuge summarizes their work and concludes that there is every indication that cratering will substantially contribute to the field of salt water marsh mosquito abatement, as well as provide an efficient and effective means of developing the salt marsh for waterfowl (Gavutis, 1963).

SAFETY

Ammonium nitrate-fuel oil mixtures (AN/FO) are not classed as explosives but as "blasting agents." However, AN/FO mixes must be considered as dangerous, and handled properly. It is the intent of this paper to promote interest and further testing of the possible uses of AN/FO to improve waterfowl and other wildlife habitat. The use of AN/FO as a blasting agent should be done under the supervision of someone experienced in the use of explosives.

SUMMARY

Various methods have been used to reclaim or improve extensive emergent-type marshes and potholes for wildlife.

Ammonium nitrate, a common commercial fertilizer, when mixed with No. 2 fuel oil, and detonated with a dynamite primer has proved to be an economical and effective technique in removing portions of dense emergent vegetation from extensive marshes and potholes, developing open water, and creating favorable habitat for wildlife.

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DISCUSSION

DISCUSSION LEADER DIEM: I would like to ask one question. We have been using this in some areas in Wyoming, and one of the problems that comes to mind is the comparative cost. Where do you draw the line with regard to a large operation? If you are doing this over a wide marsh area, where do you decide between bringing in a dragline and blasting?

MR. RADTKE: The approximate cost of this is about one-fifth of the equivalent work using dynamite. Of course, we do not want to represent this as a cure-all, since in many areas draglines will be more effective. However, in many areas the soil is such that draglines or bulldozers cannot get into the soft, mucky soils and in many of the scattered potholes through a larger area, it would be uneconomical to move a dragline from one to the other.

There are some studies going on in Wisconsin to evaluate blasting as compared to both the draglines and bulldozers. Of course, each has its advantages.

As to use by waterfowl, some studies now going on indicate that approximately 90 per cent of the reclaimed woodland potholes are being used by waterfowl.

MR. HARVEY NELSON: We have been in touch with you previously on this as to wondering what you are proposing to do with this in terms of additional publication, particularly illustrations. Do you have any thoughts along this line?

MR. RADTKE: Well, we have considered it. One of the things about this practice is that it is adaptable to such things as ACP payments or sportsmen's clubs, etc. Michigan has it on a cost-sharing basis and I understand Wisconsin is planning at least in putting it on a cost share basis with farmers and perhaps with the rural area development program. Also, we hope we can get out some type of a publication on it.

MR. ROBERT CURTIS (Michigan Department of Conservation): Have you made any comparison as far as use to wildlife production particularly is concerned?

MR. RADTKE: We initiated a study here to attempt to compare it. The only thing we have to gauge it against is what is coming out of Wisconsin and the information there indicates a very high use of these reclaimed woodlands. However, we are just starting with the administrative study on it.

MR. CURTIS: As you know, I have done some work in Michigan and have found that about a tenth of an acre was a pretty good size to start with. I think it would be pretty economical to use by states that do not have these mucky conditions in their marshlands.

MR. PHILIP AREND (Wildlife Associates): I am a private wildlife consultant in California. I have used ditching powder, propagating powder, in creating leader ditches and creating water circulation channels in the lands you described, where you cannot get in with a bulldozer or any other type of heavy equipment. My yardage cost for materials runs about 30 cents a linear yard for a hole four feet deep and eight feet wide. You can blow a half a mile of ditch at a time using Pharmex propagating ditching powder, where you only have to fuse one end and the succeeding explosions will carry the full charge.

I was curious about the cost of this explosive you mentioned. Does that include the cost of materials and does it also include your labor charges on this?

MR. RADTKE: Those costs were with labor.

MR. AREND: Does that labor include the carrying out of the material, transporting back, and all the rest?

MR. RADTKE: What we did was to figure up the total cost. In other words, we figured up the number that we knew were being blasted in any one day and divided that into what we thought our time was worth and then figured the cost of the material and worked it out on an average basis. I believe our men blasted 50 potholes in one afternoon.

VICE CHAIRMAN DIEM: Here is a good example of why we need to get some of this information in print.

I might say that we have been experimenting with this and we corresponded with some of the people in Wisconsin about these techniques. We did use ditching powder which had much greater success and much lower man-hour involvement, in that we used 50 per cent ditching powder and we were also using only two and a half pounds of ammonium nitrate. I think we might have boosted our efficiency a little higher with a better charge. However, being beginners in this game, we were rather conservative and set our charge at about 30 inches apart at a four foot depth with a posthole digger and we were blasting out a hole five feet deep and twelve to fifteen feet wide and we figured that our total cost for that was $14.98.

This is a tremendous technique, but one of the things is here illustrated and is that with all of these variations that we need to get together and get some publications out where we can see what we are working with relative to realistic cost figures.

RESEARCH AND A PRACTICAL APPROACH NEEDED IN MANAGEMENT OF BEAVER AND BEAVER HABITAT IN THE SOUTHEASTERN UNITED STATES

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The beaver population explosion in several southeastern states has resulted in ecological problems of considerable magnitude and a Pandora's box of remedies. The purpose of this paper is to give an insight into the nature and extent of the ecological problems involved in the states having excessive beaver populations, and to present the results of five years of field investigations which may offer some leads for future research.

Information concerning extent of damage, control measures in present use, and current research in progress was obtained by correspondence and/or personal conversation with timber land owners, conservation agencies, and trappers. Field trials of the use of log drains in dewatering beaver ponds have been carried on by this writer over the past five years in Alabama,[1] Mississippi, and Georgia.

[1]The work in Alabama and Georgia was conducted while author was a biologist with Soil Conservation Service.

EXTENT OF DAMAGE

Twelve of the largest timber land owners (with total well over one million acres) in Alabama and Mississippi were contacted concerning the extent of their beaver damage and the controls they used. All but one of the company representatives contacted admitted extensive beaver damage. The majority of the damage was reported as caused by flooding. This agrees with a Louisiana study by Charbrek (1958) which showed that only 18 per cent of the trees in his study area were felled, and those were of little commercial value. Less than 3 per cent of the trees that were "barked" died. One company in Mississippi claimed a $100,000.00 loss due to beaver activity, with 90 per cent of the loss attributed to flooding.

Nine southeastern state game departments were contacted concerning beaver damage; six of these states admitted having had increasing beaver damage complaints, and three of these states had excessive damage. A survey of all the county soil conservationists in Alabama was made in 1960 to obtain their estimates of the number of acres of water impounded by beaver. Central Alabama counties reported the largest acreage. Five central Alabama counties reported an overall total of 10,000 acres of land flooded by beaver.

CONTROL MEASURES IN CURRENT USE

The main control technique in use by timber companies in the reduction of the beaver population was through the use of conibear traps. This is a killing-type trap which crushes the head and chest of the beaver. However, the timber companies report varying degrees of success in trapping. One company forester reports that 417 beaver were caught over a two year period with conibear traps, and this trapping eliminated 90 per cent of his company's beaver problem. A forester for another company reported that his company purchased $1728.00 worth of conibear traps and hired a professional trapper; the net result was 48 beaver caught over a period of a year. One company reported using a trained dog with some degree of success.

The southeastern game departments, for the most part, have reported using live traps for taking beaver out of troubled areas. The Alabama Conservation Department reports trying unsuccessfully to develop a poison for beaver, while Mississippi has declared the animal a predator.

The U. S. Fish and Wildlife Service's branch of refuges apparently has no policy for management of beaver or beaver habitat in the southeastern states. One manager of a large waterfowl refuge systematically breaks beaver dams and supplies conibear trap to local trappers, yet one of his stated objectives is to double the breeding population of wood ducks. Another manager refrains from molesting beaver or their impoundments. Dynamiting is the technique most frequently used to break beaver dams for reduction in water levels.

For the most part, this technique is expensive due to the constant rebuilding activities of the beaver, especially during the late summer and early fall months.

A log drain (Arner, 1963) was used in field trials in Alabama, Mississippi, and Georgia over a period of 5 years. The main purpose of the field trials was to determine if beaver ponds could be dewatered long enough to grow a crop of Japanese millet (*Echinochloa crusgalli*) for duck food. The results of 32 field trials with nearly 700 acres of beaver flooded land showed that beaver ponds could be dewatered for 60-day periods for less than 45¢ per acre, and showed that Japanese millet could be produced in quantity at an average cost of approximately $5.00 an acre with this technique. It was also found that Japanese millet would become established the second and third year through reseeding when the ponds were redrained each summer. Only one beaver pond failed to produce a stand of millet the second year. This log drain technique was tried by the Weyerhaeuser Timber Company in Mississippi to dewater valuable timber areas. One demonstration was given by this writer, and a four-man crew broke six beaver impoundments and put in six log drains in an eight-hour day. Three months later four of the drains were still functioning properly (See Figure 1), one log drain was plugged, and one drain was bypassed with a new dam constructed below the drain (See Figure 2); however, the company engineer estimated 400 acres of valuable forest land had been dewatered very economically by this technique.

ECOLOGICAL AND ECONOMIC PROBLEMS INVOLVED

Beaver have been recognized by most waterfowl biologists as being excellent developers of waterfowl habitat. Beard (1953), in an intensive study in Michigan of the ecology and productivity of beaver habitat for waterfowl, reports that the beaver has set a pattern of optimum waterfowl development, and waterfowl managers should take advantage of the beaver's ability to create ideal waterfowl habitat. Speake (1955), in a study of waterfowl use of creeks, beaver swamps, and small impoundments in a central Alabama County, found that beaver swamps received more waterfowl use than the other sample areas when year around night and day use was considered. He also wrote that management of beaver swamps for dabbling ducks appears to offer better possibilities than does management of small man-made

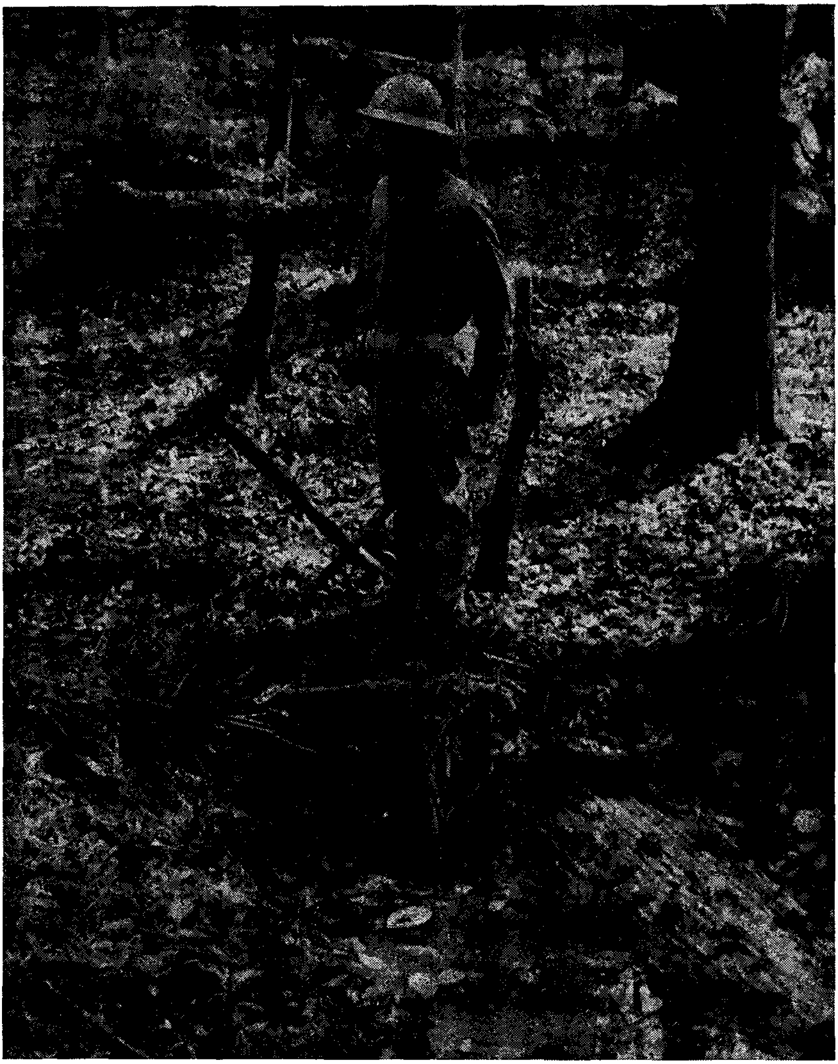

FIG. 1 Log drain 3 months after breaking dam and installing the drain. Note sticks and mud piled on top of the drain by beaver on downstreams side.

impoundments. Speake stated that beaver swamps have the following advantages over ponds:

(1) They serve as roosts for ducks and probably hold the ducks in local areas.

(2) They provide good hatching and rearing areas for wood ducks.

(3) Their great variety of vegetation due to the interspersion of various successional stages provides a wide variety of natural foods.

Destruction of beaver habitat through dynamiting beaver dams or extensive programs of eradication will most certainly reduce the winter carrying capacity for migratory waterfowl and the nesting area for wood ducks.

Evidence of the detrimental ecological effects in repeated breaking of beaver dams in the warmer months over a period of years is apparent in many areas of the South. This writer has examined well over 1,000 acres of beaver impoundments in Alabama and Mississippi where the impounded areas have been dewatered three or more years in succession. Invariably the dominant plant successions were poor food producers for ducks. Some of the dominant plants involved were swamp smartweed (*Polygonum hydropiperoides*), beggarticks (*Bidens* spp.), waterprimrose (*Jussiaea decurrens*), mint (*Mentha* spp.), penthorum (*Penthorum sedoides*), sedge (*Carex* spp.),

FIG. 2 Cross sticks indicate the location of one drain which was bypassed by beaver to build a dam approximately 75 feet below the drain.

alder (*Alnus* spp.), hibiscus (*Hibiscus* spp.), buttonbush (*Cephalanthus occidentalis*), and Hydrolea (*Hydrolea* spp.). Swamp smartweed usually dominates the dewatered areas. This is one of the aggressive invaders and frequently exerts dominance very quickly. It is a poor food producer; measured seed yields (Arner 1963) averaged only 153 pounds per acre. It is also nearly impossible to eradicate. Combination of 2,4-D and 2,4,5-T herbicides in fuel oil were tried, along with controlled burning and mowing; all proved unsuccessful in significantly reducing smartweed in dewatered beaver ponds.

The low use of swamp smartweed by dabbling ducks was very evident in a study of duck gullets collected from an 85 acre beaver dam in Greene County, Alabama. The water level in this beaver dam had been lowered by the use of a log drain. Japanese millet was sowed on 27 acres of the shallow dewatered area. In this area where millet was growing, patches of red rooted sedge (*Cyperus erythrorhizos*) grew up with the millet. Over 50 acres of the unseeded millet areas developed a solid stand of swamp smartweed. Seventeen puddle ducks (mallards, wood ducks, and blacks) were collected from the area in the winter of 1960, and the gullet contents were examined. The contents revealed that nine of the gullets were completely filled with Japanese millet and eight with red rooted sedge seed. None held swamp smartweed seed, although this plant covered twice the area that millet covered. The gullets of 17 wood ducks killed in the evening on an unmanaged beaver pond, located approximately 3 miles from a beaver pond planted to Japanese millet, were all found to contain large quantities of millet seed.

The examination of the gullet content of 14 mallards and wood ducks collected in the evening on an unmanaged beaver pond, revealed that eight of the gullets were empty and only two of the remaining six contained plant materials growing in the immediate vicinity of the beaver pond.

The reports secured from people engaged in beaver control work revealed that, for the most part, the pelt and meat are not marketed or used. Forestry personnel contacted reported that the low prices paid for beaver pelts were the reason that they did not attempt to skin and sell the beaver pelts. One forester reported that of 417 beaver caught, less than 50 were pelted. In addition, very few people seemed to be aware of the fact that properly prepared beaver meat is a real culinary delight.

Information received from trappers and the New York Fur Auction showed that $5.00 was about the average price paid for Alabama and Mississippi beaver. However, two wildlife students at Auburn

University who did a very careful skinning job, averaged nearly twice this amount, receiving as high as $15.00 each for several of the larger beaver.

RESEARCH NEEDS AND CONCLUSIONS

Although the wails of distress of the majority of timberland owners in Alabama and Mississippi were loud and long when the beaver was mentioned, their silence was deafening when asked for financial help in supporting a proposed research project concerning beaver control and ecology. Twelve of the largest and most influential timberland owners were asked to support a proposed two-year study involving these aspects; all professed interest, but none would agree to contribute. This was especially disheartening since the total budget as proposed by the Zoology Department of Mississippi State University was only $10,000, with the University pledging 25 per cent of the total cost, and the amount of money spent by one company for traps and trappers for one year would have paid half the cost of this research. The Weyerhaeuser Corporation was the only timber-land owner who volunteered to spend some money on any aspect of control other than trapping. This corporation has tried the log drain technique mentioned previously in this paper and has had good results thus far.

Only one of all the southeastern conservation departments reported having a beaver research project. Georgia reported having a study underway involving the use of drains in dewatering beaver ponds and the seeding of Japanese millet in the dewatered areas.

It is the opinion of this writer that future research work concerning the widespread activities of the beaver should have a two-fold purpose; one, to determine how to best protect the timber-land owner from excessive beaver damage; two, to determine how to preserve and utilize the extensive acreage of shallow water beaver impoundments for the benefit of waterfowl.

The first aspect, that of forest land protection, should involve the following studies: (1) Oral contraceptives should be tested to determine their ability to control expanding beaver populations. Correspondence with biologists of the Worcester Foundation in Experimental Biology and with the Upjohn Company revealed that it might be possible to sterilize male and/or female beaver with contraceptive steriods. (2) Some of the new chemical repellents should be thoroughly tested to see if these repellents would be economically feasible to make nuisance beaver move out of certain areas. (3) Investigations should also be made concerning the improvement of trapping, skinning, and marketing techniques. Wildlife extension specialists and county agents could aid in disseminating information, not only on skinning and marketing techniques, but on the palatibility of beaver meat. (4) The study of the use of drains should be expanded and should cover the entire growing season of trees.

The second aspect, that concerning how to best utilize the large acreage of shallow water beaver ponds for the benefit of waterfowl, should involve the following: (1) field trial testing of different plants, such as new Japanese millet varieties. An Asiatic variety was tried by this writer in two beaver ponds and was found to grow as rapidly as the commercial variety and to produce seed heads almost again as large as the wild or commercial varieties of *Echinochloa,* (2) studying the effect of annual draw downs on fish populations in beaver ponds, (3) investigating as to whether an increased food supply will hold native wood ducks appreciably longer in the fall, Work by Hester (1961) in North Carolina showed that on one pond with a good stand of Japanese millet, the native wood ducks remained a month longer than in other nearby ponds without millet, (4) determining whether an increased food supply would attract wood ducks to nest in the immediate vicinity of the plantings.

Since the proper management of shallow beaver ponds will provide significantly greater feeding and nesting areas for ducks in the southeastern United States, serious consideration should be given by conservation agencies to the preservation of as many of these areas as possible. The leasing of such beaver ponds would undoubtedly require some remuneration to the landowner. If only 25 per cent of the 10,000 acres of beaver flooded land reported by soil conservationists in five Alabama counties was leased and developed to grow Japanese millet, over 125,000 ducks in these five counties could be fed well for the four winter months. In addition, the maintenance of these beaver impoundments would provide nesting areas and brood cover for many wood ducks.

In this age of atom splitting, the development of a sensible scientific plan for the management of beaver and beaver habitat should be entirely possible through well-coordinated research by conservation agencies, timber land owners, and universities.

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DISCUSSION

MR. ERNET PAYNTER (Saskatchewan): I listened to this paper with great interest. Up in Canada, of course, we get better prices for our beaver, and this, of course, helps in our difference with the exchange rate when we come to your meetings.

Now, I did not hear you refer to the old Victor trap or to the Conibear. We find the Conibear is the most efficient trap and, since we have started instructing our trappers in the use, our beaver take has increased.

DR. ARNER: I would agree with you, sir. I think the Conibear trap is the most efficient trap and that is one of the reasons that actually you will find some objection to it in the deep South—because foresters cannot see the trap and, further, they do not visit it but once a week and the beaver pelt has deteriorated under water. However, with these other traps, beaver frequently get one foot in there and can get out and, as a result, they become wiser and they are more difficult to trap.

CHAIRMAN JONES: I wish to thank all of you for your participation. You have been an attentive audience. I also wish to thank all of those who presented these excellent papers. We are now recessed.

TECHNICAL SESSION

Monday Afternoon—March 9

Chairman: L. DALE FAY
Pathologist, Rose Lake Experiment Station, Michigan Department of Conservation, East Lansing

Discussion Leader: WELDON ROBINSON
Chief, Section of Control Methods, Wildlife Research Center, Bureau of Sport Fisheries and Wildlife, Denver, Colorado

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DISEASE, NUTRITION AND CONTROL

FOODS AND NUTRITION OF MISSOURI AND MIDWESTERN PHEASANTS[1]

LEROY J. KORSCHGEN
Missouri Conservation Commission, Columbia, Missouri

This paper reports the results of ten years' research to learn foods, feeding habits, and nutrition aspects of the ring-necked pheasant, *Phasianus colchicus torquatus,* in Missouri and other midwestern states. Special objectives related to factors that may affect distribution of pheasants included: (1) principal seasonal and year-round foods, by sex; (2) importance of agricultural crops and native foods; (3) proximate chemical composition of wild pheasant diets; and (4) sources and amounts of minerals, particularly calcium, obtained by birds in occupied range.

The study initially pertained only to Missouri, but later phases included materials from eight additional states: Iowa, Michigan, Minnesota, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

[1]This study was done with cooperation of Federal Aid in Fish and Wildlife Restoration funds under Project, Missouri 13-R. Special thanks for assistance are due K. C. Sadler and G. D. Chambers, biologists, Missouri Conservation Commission; refuge personnel, U. S. Fish and Wildlife Service; and cooperating biologists in states of the Midwest Pheasant Council Area.

METHODS

Study materials were first obtained during November, 1954, coincident with Missouri's first statewide pheasant hunting season without special permit. Pheasant crop and gizzard contents were requested from hunters and landowners in the established pheasant range to whom the Conservation Commission supplied materials for submitting samples. Collections were made in this manner through the 1959 season, with a total of 105 samples received. Five December samples were obtained from managers of commercial shooting preserves in 1957, and 197 birds were collected under special permit from the Squaw Creek Refuge Area, Holt County, Missouri, during all months except November, 1958-1960. A few additional samples were obtained from birds on separate experimental release areas in Boone Linn, and Audrain counties, bringing the total to 319 Missouri samples examined.

Foods were separated by kind, identified, weighed, and measured in accordance with standard food habits study procedures.

Plant classification as used in this report essentially follows that of Gray's Manual of Botany, Eighth Edition (Fernald, 1950).

REVIEW OF LITERATURE

The versatile feeding habits of the ring-necked pheasant have been documented by many investigators, who have found a great variety of foods acceptable to this bird. The predominance of cultivated grain in the diet is striking, in view of the abundant weedy cover in pheasant habitat. Most investigators believe, however, that the bulk of grain is gleaned from the fields after harvest, representing agricultural waste. Corn, wheat, barley, and oats usually class as the most important foods in South Dakota, as shown by Trautman (1952) who examined 1,416 pheasant crops; and Severin (1936) from 285 samples. Fried (1940), with 659 crops and gizzards from Minnesota, found the same "big four" foods, as did Hiatt (1946) from 500 Montana pheasants. Other studies that showed essentially the same results were: Dalke (1937), with 304 crops from Michigan; Mohler 1949), 160 crops, and Swenk (1930), with 87 crops from Nebraska; Burnett and Maxon (1921), with 48 crops from Colorado; Cottam (1929), 45 crops from Utah; and Munroe (1940), with an undisclosed number from North Dakota.

Ragweed was listed next to corn in importance by Hicks (1936), with 92 crops from Ohio; Bennett and English (1939), 423 crops, and English and Bennett (1940), with 84 crops from Pennsylvania; Gigstead (1937), 141 crops; and Rossbach (1946), with 353 crops from Wisconsin.

In California, rice replaced corn as the leading food, according to Ferrel, Twining, and Herkenham (1949). The absence of corn reflected a lack of availability, but wheat and barley rated high.

Pheasants in the northeastern states departed somewhat from the normal in feeding habits. McLaughlin (1942), from 70 crops in Massachusetts, reported skunk cabbage as the leading food, followed by corn, insects, dogwood and grape. Wright (1941) reported corn, bayberry, skunk cabbage, viburnum, and rose as the principal foods of 32 pheasants in Rhode Island. Shick (1952) found that 20 Michigan pheasants lived almost entirely upon corn and white beans during the winter and spring.

FINDINGS AND ANALYSIS

The principal foods of 319 pheasants in Missouri comprise Table 1. Data are presented by season and year-round.

Fall foods are represented by 114 samples. A total of 140 plant and 26 animal items were identified. Of these, seven plant foods and grasshoppers amounted to 1.0 per cent or more each, by weight. Three samples were obtained during September, six during October, and the remainder during the November 10-25 hunting seasons. Corn, soybeans, cane, and wheat comprised more than three-fourths of the diet for this period. Great ragweed, giant foxtail, and annual sunflower were important wild foods. Grasshoppers and ground beetles also were important during fall.

Winter foods (December, January, and February) were represented by 74 samples, five of which were obtained from commercial pheasant shooting farm releases and the remainder from special collections on Squaw Creek Refuge. A total of 113 plant and 27 animal foods were identified, of which eight plant foods amounted to 1.0 per cent or more each, by weight. No animal food was important during winter, although the variety eaten was as great as during fall. Corn was the staple food during winter as two-thirds of all food. Except for cane and soybeans, other important foods were from native plants, particularly dayflower, bur-cucumber, and false buckwheat.

Spring foods represent pheasant feeding during March, April, and May, prior to and during the production period. A total of 114 plant and 50 animal foods were identified in the 86 samples examined. Six plant foods were important, by weight. No animal food was taken in important amount by weight, although great numbers of ants were consumed during this period. Corn and dayflower were dominant foods each month. Water smartweed rated third in March, bur-cucumber in April, and green leaf material in May.

Data for summer (June, July, and August) are more limited. In

TABLE 1: PRINCIPAL FOODS OF PHEASANTS IN MISSOURI, 1954–1960
(Based upon percentage by weight in 319 crops and/or gizzards)

Food Item	Season: Samples:	Fall 114	Winter 74	Spring 86	Summer 45	Year 319
Corn, *Zea Mays*		66.9	72.1	65.0	29.5	64.8
Dayflower, *Commelina communis*		0.7	7.9	17.5	—	8.4
Soybeans, *Glycine max*		10.8	1.5	—	0.1	3.3
Giant foxtail, *Setaria Faberii*		3.1	0.7	0.9	12.3	2.4
Bur-cucumber, *Sicyos angulatus*		0.4	4.3	2.6	0.3	2.4
Wheat, *Triticum aestivum*		1.4	—	trace	19.0	2.0
Cane, *Sorgum vulgare*		4.0	1.6	trace	trace	1.6
False buckwheat, *Polygonum scandens*		0.2	2.6	1.5	trace	1.4
Rice, *Oryza sativa*		—	trace	0.1	14.7	1.3
Yellow foxtail, *Setaria glauca*		0.5	0.2	trace	9.2	1.0
Water smartweed, *Polygonum punctatum*		trace	0.1	2.8	trace	0.9
Great ragweed, *Ambrosia trifida*		2.4	0.2	0.7	—	0.9
Pin-oak acorns, *Quercus palustris*		0.2	2.3	—	—	0.8
Green leaf material		0.1	0.8	1.2	0.9	0.7
Gray dogwood, *Cornus racemosa*		0.4	0.8	0.6	trace	0.6
Hackberry, *Celtis occidentalis*		trace	1.1	0.5	—	0.5
Pinkweed, *Polygonum pensylvanicum*		0.4	0.5	0.3	0.5	0.4
Pokeweed, *Phytolacca americana*		trace	0.8	0.3	—	0.4
Annual sunflower, *Helianthus annuus*		1.2	trace	0.1	trace	0.3
Nimble-will stolons, *Muhlenbergia* sp.		—	0.7	0.3	—	0.3
Japanese millet, *Echinochloa frumentacea*		0.3	trace	—	2.6	0.3
Smooth sumac, *Rhus glabra*		0.2	0.2	0.5	trace	0.3
Chufa tubers, *Cyperus esculentus*		0.1	trace	0.7	0.4	0.3
Tubers, unclassified		—	—	0.7	—	0.2
Wild cherry, *Prunus serotina*		0.2	trace	trace	1.0	0.2
Grass leaves		0.1	0.3	0.1	trace	0.1
Wild grape, *Vitis* sp.		0.2	trace	0.2	trace	0.1
Slender nettle, *Urtica procera*		—	0.3	—	—	0.1
Ground cherry, *Physalis* sp.		0.3	trace	trace	0.1	0.1
Small crab-grass, *Digitaria Ischaemum*		0.1	trace	trace	0.7	0.1
Bristly greenbrier, *Smilax tamnoides*		trace	trace	0.2	trace	0.1
Barley, *Hordeum vulgare*		trace	trace	0.3	—	0.1
Trailing wild bean, *Strophostyles helvola*		0.3	—	—	—	0.1
Hawthorn, *Crataegus* sp.		0.2	trace	trace	—	0.1
Green foxtail, *Setaria viridis*		0.2	trace	trace	0.2	0.1
Cleavers, *Galium* sp.		trace	0.1	trace	trace	0.1
Short-horned grasshoppers, Acrididae		1.6	trace	trace	0.8	0.5
Ants, Formicidae		trace	trace	0.4	1.2	0.2
Ground beetles, Carabidae		0.6	trace	trace	0.3	0.2
Snout beetles, Curculionidae		trace	trace	0.1	1.3	0.2
Long-horned grasshoppers, Tettigoniidae		0.3	—	—	0.2	0.1
Leaf beetles, Chrysomelidae		trace	trace	0.1	0.5	0.1
Insect larvae and unclassified		trace	trace	0.2	0.1	0.1
Moth and caterpillars, Lepidoptera		—	trace	0.1	0.2	0.1
Calcium bearing grit		0.1	0.2	0.4	1.5	0.4
Percentage of total diet		97.5	99.3	98.4	97.6	98.7
Total Food & Calcium Bearing Grit (Grams)		880.3	1150.7	1080.7	293.2	3404.9

45 samples, 80 plant and 41 animal items were identified. Corn retained its first place rating for the season, but was second to rice during June, and amounted to only a "trace" during August. Rice is an important but restricted crop on Squaw Creek Refuge where the birds fed heavily upon this item after planting. Use of wheat increased from June through August and rated second among summer foods. Giant and yellow foxtail grasses were heavily used in August when each species comprised more than one-fourth of the total diet. Japanese millet and wild cherries also rated well during summer. Snout beetles (curculios), ants, grasshoppers, and leaf beetles were important animal foods.

Year-round, the diversified feeding of pheasants parallels that of quail and other ground-feeding birds. The diet includes many items that are taken only occasionally and perhaps incidentally. A total of 200 plant and 68 kinds of animal foods were identified. Ten plant foods, consisting of five cultivated grains—corn, soybeans, wheat, cane, and rice, and five native foods—dayflower, giant foxtail, bur-cucumber, false buckwheat and yellow foxtail comprised 1.0 per cent or more each, by weight, of the year-round diets of 319 birds (Table 1).

USE OF AGRICULTURAL CROPS

The extensive utilization of corn, soybeans, wheat, cane, rice, barley, oats, alfalfa, rye, and rape reflects the intensive agricultural use of Missouri's principal pheasant ranges. Cropland constitutes about 70 per cent of the land area, of which 25-50 per cent is planted to corn, and 15-35 per cent is kept in legume crops (Christisen, 1951). Small grains are less extensively grown on the fertile bottomland soils where pheasant production is best.

The ten agricultural crops made up 67.4 per cent of the pheasant diet, by volume, and 73.3 per cent, by weight, in the year-round diet. By season these amounts were: 77.2 and 83.4; 69.5 and 75.2; 59.7 and 65.7; and 61.9 and 64.5 per cent for fall, winter, spring, and summer, respectively.

NUTRITIONAL ANALYSES

Investigation of the proximate chemical compositon of the pheasant diet was begun during fiscal year 1957-58. Two factors were chosen for study: (1; the quality of foods grown on soils which support pheasants, for comparison with the quality of the same kinds of foods grown on soils that do not support pheasants; and 2) the source and supply of calcium as a possible limiting factor to pheasant distribution in Missouri.

The fall foods of Missouri pheasants for three years were used as a basis for this study. Ten principal foods were collected for analyses: corn, soybeans, cane, annual sunflower, great ragweed, giant foxtail, wheat, barnyard-grass (substituted for Japanese millet), yellow foxtail, and grasshoppers. These included all foods that comprised 0.5 per cent or more each of the pheasant diet as then known.

Seeds were collected on two widely separated areas: the fertile Wabash soils of Squaw Creek Refuge, Holt County, which supported a good pheasant population; and the less fertile Putnam soils of northern Boone County, where pheasants have failed to become established.

Samples of both lots of seeds were chemically analyzed by Ralston

TABLE 2. COMPOSITION OF PHEASANT FOODS

Food	Source	Moisture	Protein	Fat	N.F.E.	Fiber	Ash	Ca	P
Alfalfa (leaves)	NRC[a]	11.00	21.30	2.80	40.60	15.00	9.50	2.38	.29
Apple	NRC	9.00	5.40	4.70	63.00	16.00	1.90	.13	.12
Barley	NRC	11.00	11.60	1.90	67.80	5.00	2.70	.09	.47
Barnyard-grass	Local[b]	8.75	12.90	4.52	50.92	16.70	6.21	.01	.47
Bean, navy	Morrison[f]	10.00	22.90	1.40	57.30	4.20	4.20	.15	.57
Buckwheat	NRC	12.00	11.10	2.50	63.40	9.00	2.00	.13	.38
Buckwheat, false	Local	8.70	14.13	2.53	64.70	7.61	2.33	.14	.28
Bur-cucumber	Local	5.05	29.00	22.20	12.75	26.00	5.00	.15	.79
Burdock	Spinner and Bishop	38.65	9.46	10.21	21.52	16.97	3.19	—	—
Cane	Local	9.88	12.20	3.65	64.68	5.93	3.66	.06	.42
Cherry, wild	King and McClure[f]	6.71	13.00	6.50	40.11	30.47	3.45	.42	.20
Chufa	King and McClure[f]	9.86	4.47	26.63	49.95	8.08	1.54	.03	.61
Clover, Ladino	NRC	9.00	21.10	3.10	40.10	18.00	8.70	1.38	.40
Coralberry	King and McClure[f]	6.98	7.91	5.83	55.61	19.91	3.94	.40	.22
Corn	Local (S.D.)[c]	13.50	10.50	3.29	68.91	2.48	1.32	.15	.22
Dandelion	Bump and Jones	10.00	23.04	4.12	38.80	11.19	12.85	—	—
Dayflower	Local	9.50	22.50	.39	54.88	3.51	9.22	.47	.45
Dogwood, gray	Local	6.40	6.66	30.00	25.78	25.30	5.86	1.32	.28
Elderberry	Bishop and Spinner	9.59	8.31	13.31	42.70	20.78	5.13	—	—
Flax	NRC	9.00	15.80	9.40	47.10	12.00	6.70	.37	.43
Foxtail, giant	Local	6.56	15.20	4.61	47.21	19.50	6.92	.10	.40
Foxtail, green	Local (S.D.)[c]	12.20	17.50	5.35	53.14	7.62	4.19	.07	.25
Foxtail, yellow	Local	6.18	19.40	5.77	41.00	20.50	7.15	.14	.47
Goosefoot	Spinner and Bishop	12.17	20.13	8.30	45.50	11.12	2.78	—	—
Grasses, mixed, green	Morrison	10.00	15.45	4.64	41.81	19.09	9.09	—	.09
Grape, wild	King and McClure[f]	7.90	9.04	8.77	50.07	20.46	4.07	.52	.26
Greenbrier	King and McClure[f]	7.58	9.46	6.96	56.16	17.18	3.14	.25	.16
Hackberry	Local	9.09	5.18	4.44	38.07	5.12	38.10	12.20	.21
Honeysuckle, Jap.	King and McClure[f]	10.56	9.31	7.03	62.04	5.95	5.46	.66	.31
Jewelweed	King and McClure[f]	6.01	26.53	41.87	18.41	2.77	4.51	.47	.97
Jimsonweed	Spinner and Bishop	4.55	17.88	15.76	16.33	42.37	3.11	—	—
Locust, black	King and McClure[f]	7.42	43.19	11.08	21.89	15.12	3.99	.25	.90
Manure, cow, dry	NRC	6.00	12.20	2.70	34.20	27.00	17.90	1.89	.66
Mustard	Spinner and Bishop	9.48	19.45	15.23	35.70	15.16	4.98	—	—
Nannyberry	Spinner and Bishop	10.78	5.70	10.19	61.60	9.30	2.43	.12	.04
Nettle (Urtica)	Spinner and Bishop	4.95	24.75	17.75	27.33	14.88	10.34	—	—
Oats, tame	Local	7.45	14.10	4.65	56.49	13.60	3.71	.11	.30
Oats, wild	NRC	11.00	11.70	5.60	52.10	15.00	4.60	—	—
Olive, Russian	Borell[f]	8.84	9.12	5.41	58.04	15.63	2.95	.15	.12
Pea	Morrison	10.80	25.30	1.70	53.60	5.70	2.90	.08	.40
Pinkweed	Wright	3.14	9.00	3.19	67.16	15.93	1.58	—	—
Pin-oak acorns	Local	11.60	4.99	17.60	51.91	12.20	1.70	.16	.13
Poison ivy	Wright	3.38	6.75	26.09	32.15	30.10	1.53	—	—
Pokeweed	Spinner and Bishop	13.85	10.61	6.64	55.46	10.19	3.26	—	—
Proso millet	NRC	10.00	11.80	3.60	64.60	7.00	3.00	—	.48
Ragweed, common	King and McClure	7.08	22.77	12.52	22.79	31.69	3.37	.36	.56
Ragweed, great	Local (S.D.)	3.20	18.80	23.60	20.73	29.70	3.97	.30	.07

Rice	Local	5.81	6.92	2.63	69.20	9.33	6.11	.04	.26
Rose, Japanese	King and McClure	5.56	9.48	5.73	53.41	21.85	4.09	.90	.33
Rose, wild	King and McClure	5.74	10.14	6.62	44.36	29.10	4.24	.89	.20
Rye	NRC	11.00	11.90	1.60	71.60	2.00	1.90	.07	.38
Sedge	Spinner and Bishop	10.30	11.06	3.98	48.96	21.40	4.28	—	—
Smartweed, water	Local	8.94	11.60	4.01	52.91	9.14	13.40	.36	.34
Soybeans	Local	6.03	38.10	19.30	25.67	5.08	5.82	.23	.67
Summer cypress	Local (S.D.)	9.80	20.10	10.60	43.36	8.87	7.27	.41	.43
Sudan grass	Morrison	7.60	14.20	2.40	38.40	25.40	12.00	—	—
Sumac, smooth	King and McClure	5.33	4.94	16.29	43.39	27.25	2.88	.48	.24
Sunflower, annual	Local	4.68	19.50	26.10	16.08	30.20	3.44	.24	.62
Sunflower, mixed	Local (S.D.)	3.72	19.30	22.10	25.34	25.80	3.74	.26	.62
Wheat	Local	11.40	13.80	3.35	66.96	2.69	1.80	.06	.39
Wheatgrass	Morrison	20.00	2.20	0.90	41.90	32.10	2.90	.14	.08
Ant, carpenter	Bump and Jones	10.00	27.18	4.90	22.27	10.03	25.62	—	—
Beetles, mixed	Beck and Beck	10.00	53.57	3.94	—	28.97	4.97	1.21	.17
Caterpillars	Beck and Beck	10.00	40.34	4.25	23.68	18.15	3.58	1.05	.14
Earthworms	French, et al	10.00	48.15	5.41	15.68	—	20.76	—	—
Grasshoppers	Local	9.52	70.50	5.73	—	11.30	5.67	.23	.69
Misc. insects, etc.	Beck and Beck	10.00	62.92	2.14	3.11	19.49	2.34	1.31	.26
Snails, tadpole	Univ. of Mo.	1.66	11.75	0.81	3.57	2.43	79.78	27.34	.25
Eggshell	Romanoff and Romanoff							39.15	
Limestone	Univ. of Mo.							37.68	

[a] National Research Council Report
[b] Ralston Purina Co. analyses of Missouri seeds
[c] Ralston Purina Co. analyses of South Dakota seeds
Data converted from moisture free basis:
King and McClure
Beck and Beck
French, et al
Borell
Morrison

Purina Company, St. Louis, which assistance is hereby gratefully acknowledged. Methods of analyses were generally those outlined in the Journal of the Association of Official Agricultural Chemists, Eighth Edition, 1955. Additional seed samples were collected in Holt County during fall, 1958, including rice, bur-cucumber, smooth sumac, water smartweed, false buckwheat, and gray dogwood. Hackberry was collected in Ray County and pin-oak acorns in Chariton County. Analyses of these also were performed by the Ralston Purina Company, as were nine samples of foods collected in the Lake Andes area of South Dakota during October, 1958. Results of these analyses comprise Table 2, in part. Additional chemical analyses of selected plants were added from other published sources to comprise a more comprehensive list.

The analyses of Missouri seeds grown on Wabash and Putnam soils showed only a fractional percentage difference in chemical composition by type. Similar findings were reported by Spinner and Bishop (1950) for wildlife foods in Connecticut.

In order to learn the component values of a diet comprised entirely of the ten items initially collected in Missouri, calculations were based upon actual percentages, by weight, in the fall diet of cock pheasants and adjusted to a total diet. The results for Holt and Boone counties, and equivalent data for 71 male pheasants collected in South Dakota, October, 1958, comprise Table 3. South Dakota data are based upon a complete diet of the nine principal foods identified in the crop contents.

The fall diet of pheasants in South Dakota does not reflect a superiority over that available to Missouri birds. Protein and fat levels are lower, while carbohydrate is slightly higher. Mineral (ash) amounts are greater in the Missouri diet, but the calcium level in South Dakota is about twice as great as in Missouri.

Dale and DeWitt (1958) reported from experimental feeding of penned pheasants that a high protein level was required for growth and production. Birds on 15 and 18 per cent levels of protein grew at about one-half the rate of those on a 28 per cent level. Birds on a 22 per cent protein ration grew at a reduced rate, but were only slightly below the controls at 10 weeks of age. Protein level of the winter diet had little influence on subsequent reproduction, provided

TABLE 3: COMPOSITION OF FALL COCK PHEASANT DIETS IN MISSOURI AND SOUTH DAKOTA

Location	Moisture	Protein	Fat	N.F.E.	Fiber	Ash	Ca	P
Boone County, Mo.	8.93	15.52	7.40	60.74	3.78	3.54	.069	.357
Holt County, Mo.	9.58	15.28	7.29	59.68	3.81	4.15	.051	.394
South Dakota	12.39	10.88	3.58	65.32	4.04	1.65	.139	.228

the reproductive diet was satisfactory. Production of eggs and young birds was low for all pheasants on diets containing less than 25 per cent protein.

According to the findings of Dale and DeWitt (1958), rations composed of Holt and Boone counties (Missouri) plant foods in the fall diet both rate low in protein for growth and production. These diets, however, are sufficient to maintain adult male birds, since they live and produce on the Holt County range. Hens and young birds would need to supplement their diets by greater consumption of protein-rich animal foods during periods of production and growth.

Mineral requirements for pheasants, especially calcium needs, also were reported by Dale (1954, 1955) and Dale and DeWitt (1958). Dale concluded originally that pheasants on granite grit could not produce and that a 0.5 per cent calcium level in the diet (250 milligrams per day) was minimum for production and survival. Birds with about 0.5 per cent calcium gave fair production but suffered very high mortality the next winter. Dale and DeWitt later concluded that pheasants require 600 milligrams of calcium per day (calculated as 1.2 per cent of the diet, by weight; for good production, and that if birds cannot obtain a diet with better than 0.5 per cent calcium they cannot maintain the population.

Scott, Holm, and Reynolds (1958), working with penned pheasants at the Ithaca Game Farm, New York, concluded that the minimum calcium requirement for normal bone ash was approximately 1.2 per cent, which confirms results obtained by Dale and DeWitt (1958).

The data show that diets composed of Holt and Boone counties foods are greatly deficient in calcium during fall. Plant foods from Holt County (Wabash soil) supplied only about one-twentyfourth the pheasant's production needs for calcium, while Boone County (Putnam soil) foods were only slightly higher with one-seventeenth of the minimum requirement.

This indication of a possibly drastic calcium deficiency gave rise to the question of where pheasants on the Wabash soils obtain their supply, since they have demonstrated their ability to live there. In search for additional sources of calcium, an examination was made of all gravel in crop and gizzard contents. Grit from each sample was weighed and measured, after which it was immersed in dilute hydrochloric acid as a check for free calcium. Particles that effervesced freely were classed as calcium-bearing grit, removed quickly from the acid, washed, dried, weighed and measured. This method showed that gravel used by pheasants consisted largely of calcium-free, quartz-like or other grit.

It became apparent from this initial study that analyses of male pheasant foods would not supply information most critically related to pheasant production and growth. Dietary components calculated from these data invariably failed to measure up to requirements shown by penned pheasant studies. The possibility of differential feeding habits, by sex and age, was indicated.

Forty-three female pheasants were collected from January through July, 1959, and 1960, to determine whether there was (1) a differential amount of gravel taken by the two sexes, and (2) a differential amount of calcium-bearing foods taken, by sex, during the production period.

Plant foods were not greatly different, by kind, between sexes during production. Animal foods were taken in considerably greater amounts by female pheasants, particularly during April, May, and June, when percentages were 3.2, 4.7, and 6.0, respectively. Animal foods for males during the same three months were: 0.5, 2.8, and 0.2 per cent, respectively, by weight. Snails, which are calcium-rich, were selected by females, especially during April and June, when these foods comprised 1.1 and 0.9 per cent of the diet of all hens. Snails in the male diet amounted to a "trace" and none. Snails also were evident in the May diet of females, but less important than during April and June. Eggshell also appeared as a calcium-rich food in the May diet of females.

Grit consumption did not vary greatly in amount or composition during January, February, or March. Hens during April and May consumed slightly greater amounts of gravel than did the males, but differences probably were not significant. The differences in amount of calcium-bearing grit (limestone) during April was striking. Hens during April contained 33 times as much calcium-bearing grit as did the male birds. This shows a definite ability of the birds to select this type of material, as reported by McCann (1939), and Sadler (1961).

Analyses of Missouri limestone, as used for road surfacing and agricultural practices, showed a calcium content of 37.68 per cent. Whole tadpole snails, *Physa* sp., contained 27.34 per cent calcium.

Male birds did not show a proclivity for the calcium-rich foods during any period. By April the calcium level in the hen diet reached a seasonal high as 2.33 per cent of the total diet, by weight. Calcium levels remained high during May as 1.35 per cent of total food, while sources in June were mainly grit and snails and the amount (1.33 per cent) nearly equalled that in the May diet (Table 4).

These calculations showed that female pheasants in Holt County were capable of supplying their calcium requirements during the production season by use of greater quantities of snails and calcium-

TABLE 4: COMPOSITION OF MISSOURI FEMALE PHEASANT DIETS, BY MONTH, JANUARY-JULY

Month	No. Birds	Moisture	Protein	Fat	N.F.E.	Fiber	Ash	Ca	P
January	5	8.17	17.84	7.12	51.77	9.60	5.50	.241	.279
February	1	8.92	18.94	10.08	43.15	13.16	5.74	.402	.399
March	5	12.75	11.88	4.86	64.33	4.57	1.60	.147	.261
April	10	11.51	12.69	4.47	59.17	5.13	3.64	2.325	.281
May	8	11.15	16.14	2.20	58.96	3.63	5.60	1.348	.323
June	6	8.80	10.98	2.96	63.95	7.58	4.89	1.330	.330
July	8	13.07	11.21	3.36	66.78	3.68	1.56	.294	.246

bearing grit than normally are consumed by females during other seasons, or by male birds.

Components of the seasonal diets of mixed-sex and age Missouri birds comprise Table 5. Protein levels range from 12.76 to 15.92 per cent by seasonal analyses, with a year-round average of about 14 per cent.

Fat levels in the Missouri pheasant diets generally were high in fall and winter (6.21 and 4.80 per cent, respectively) and decreased to 3.99 and 3.89 during spring and summer, respectively. The fat-rich foods of gray dogwood, sunflower, great ragweed, bur-cucumber, and soybeans are important pheasant foods that contain fat levels in the 20 to 30 per cent range. These foods are consumed in greatest amounts during fall and winter.

The carbohydrate fraction of the diet appears satisfactory for all seasons by known standards. This nitrogen-free extract component varied from 58 to 62 per cent.

Phosphorus levels appear low in the Missouri diets. Dale and De-Witt (1958) found it necessary to provide 385 milligrams per kilogram per day of phosphorus (calculated as .77 per cent of the diet) to obtain satisfactory production of eggs and young, and this production was obtained only from birds that had received adequate calcium and phosphorus in the winter. Phosphorus amounted to .25 to .40 per cent in average female diets, January-July, in this study. In the all sex and age diets, phosphorus ranged from .27 to .36 per cent, but this in no case included the phosphorus contribution from grit.

TABLE 5: COMPOSITION OF SEASONAL AND YEAR-ROUND, MIXED SEX AND AGE, MISSOURI PHEASANT DIETS

Season	No. Samples	Moisture	Protein	Fat	N.F.E.	Fiber	Ash	Ca	P
Fall	114	11.50	15.92	6.21	58.07	5.50	2.51	.321	.316
Winter	74	12.14	12.76	4.80	62.45	4.79	2.88	.408	.270
Spring	86	11.85	13.55	3.99	61.58	4.65	3.78	.593	.330
Summer	45	9.62	14.22	3.89	57.59	9.20	4.20	1.099	.361
Year-round	319	11.69	13.98	4.80	60.69	5.27	3.15	.514	.297

FOODS OF JUVENILE PHEASANTS

Fourteen young birds were collected during July and August, 1959, to obtain information on the feeding habits of young pheasants. The plant diet of juvenile birds did not differ greatly from that of adults, except that somewhat smaller seeds were consumed.

The composition of juvenile pheasant diets was calculated as: moisture, 10.67; protein, 17.28; fat, 4.39; NFE, 53.81; fiber, 8.28; ash, 3.87; calcium, 1.241; and phosphorus, .377 per cent.

The protein fraction, therefore, was slightly higher than for adults. Animal foods were not exceptionally high as 8.7 per cent of the total food. These findings fail to support the generally accepted premise that the growth diet of wild pheasants is largely insectivorous and, therefore, not likely to be deficient in protein. These birds, however, were larger than quail-size and estimated to be 6-10 weeks of age. It is probable that younger birds during the first four weeks would have been found to contain a much higher proportion of insects and consequently a greater amount of protein in the diet. Dalke (1935), in Michigan, reported that animal foods made up about 90 per cent of the young pheasant diet during the first week, but declined to about two per cent at about 10 to 12 weeks of age. Trautman (1952) found that South Dakota young pheasants consumed 36 per cent animal matter in July, 35 per cent in August, and 22 per cent in September.

The data show the ability of young birds to select grit to fill their calcium needs. Twelve of the 14 birds contained limestone grit that amounted to 41 per cent, by volume, and 35 per cent, by weight, of all grit consumed. This far exceeds frequency, volume, or weight of calcium-bearing grit normally found in adult birds.

FOODS OF MIDWESTERN PHEASANTS

Termination of the study of Missouri birds in 1960, with evidence of differences in feeding habits of male and female pheasants, particularly during the reproductive season, left the desire to learn whether these differences pertained throughout the midwestern pheasant range. Additional samples were requested and received from biologists in other states of the Midwest Pheasant Council Area. Samples were collected monthly, January through June, as possible, and received from Iowa, Michigan, Minnesota, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. Data from analyses of these samples were combined with applicable Missouri data to represent nine midwestern states. Number of samples by month and state comprise Table 6.

A total of 997 pheasant crops and gizzards were examined. These represented 442 males and 555 females. Analyses were performed

TABLE 6: NUMBER AND SOURCE OF MIDWESTERN PHEASANT SAMPLES

State	January	February	March	April	May	June	Total
Males:							
Iowa	0	0	3	6	2	0	11
Michigan	3	4	10	8	4	4	33
Minnesota	3	6	8	9	10	3	39
Missouri	16	22	26	17	13	10	104
Nebraska	2	1	12	13	6	3	37
North Dakota	10	13	20	23	11	9	86
Ohio	15	16	17	14	18	0	80
South Dakota	7	5	7	11	9	3	42
Wisconsin	0	0	4	4	1	1	10
Totals	56	67	107	105	74	33	442
Females:							
Iowa	0	0	3	6	4	1	14
Michigan	4	9	12	10	9	1	45
Minnesota	5	13	8	10	14	11	61
Missouri	5	1	5	10	8	6	35
Nebraska	1	9	7	11	10	0	38
North Dakota	13	22	57	20	13	9	134
Ohio	39	26	9	46	32	9	161
South Dakota	6	5	9	13	13	8	54
Wisconsin	0	0	5	2	6	0	13
Totals	73	85	115	128	109	45	555

TABLE 7: PRINCIPAL FOODS OF 442 MIDWESTERN MALE PHEASANTS, JANUARY-JUNE, 1959–1963
(Figures are percentages, by weight)

Food Item	Month: No. Samples:	Jan. 56	Feb. 67	Mar. 107	Apr. 105	May 74	June 33	All 442
Corn, *Zea Mays*		71.7	72.3	59.5	56.6	78.6	49.9	65.7
Wheat, *Triticum aestivum*		2.2	3.3	10.3	18.0	6.4	20.5	8.5
Oats, *Avena sativa*		8.4	1.6	5.8	3.2	1.4	4.7	4.6
Dayflower, *Commelina communis*		4.0	1.2	3.4	8.7	—	—	3.6
Barley, *Hordeum vulgare*		0.8	2.4	4.1	3.7	1.8	6.0	2.9
Soybeans, *Glycine max*		4.1	3.0	2.1	0.4	4.6	4.0	2.7
Cane, *Sorgum vulgare*		1.3	0.9	1.1	1.5	2.6	—	1.3
Flax, *Linum usitatissimum*		0.8	3.8	1.3	trace	—	—	1.2
Wild oats, *Avena fatua*		0.1	0.8	1.9	0.7	—	trace	0.9
Bur-cucumber, *Sicyos angulatus*		trace	2.3	0.4	0.9	—	—	0.7
Summer cypress, *Kochia scoparia*		0.6	0.4	1.3	trace	—	—	0.6
Water smartweed, *Polygonum punctatum*		trace	trace	1.8	trace	trace	—	0.6
Nannyberry, *Viburnum Lentago*		—	—	1.7	—	—	—	0.6
Green leaf material		trace	1.0	0.1	0.5	0.8	0.4	0.4
Bindweed, *Polygonum convolvulus*		trace	1.6	0.3	trace	—	0.1	0.4
Burdock, *Arctium minus*		1.5	trace	trace	0.2	—	—	0.3
Proso, *Panicum miliaceum*		0.2	0.1	0.8	trace	—	—	0.3
False buckwheat, *Polygonum scandens*		0.4	0.1	0.5	0.2	—	—	0.3
Green grass		0.1	1.1	0.1	0.3	trace	—	0.3
Green foxtail, *Setaria viridis*		trace	0.1	0.8	trace	trace	—	0.3
Pin-oak acorns, *Quercus palustris*		—	—	—	1.6	—	—	0.3
Jewelweed, *Impatiens capensis*		0.9	—	0.1	trace	trace	—	0.2
Rice, *Oryza sativa*		—	—	—	—	—	8.5	0.2
Buckwheat, *Fagopyrum sagitattum*		—	trace	—	1.2	—	—	0.2
Goosefoot, *Chenopodium* sp.		trace	1.0	trace	trace	trace	—	0.2
Hackberry, *Celtis occidentalis*		0.5	0.2	0.1	—	—	—	0.2
Pokeweed, *Phytolacca americana*		0.2	0.4	0.1	0.2	—	—	0.2
Russian olive, *Elaeagnus angustifolia*		—	trace	0.1	—	—	—	0.2
Yellow foxtail, *Setaria glauca*		trace	0.5	0.1	trace	trace	—	0.1
Giant foxtail, *Setaria Faberii*		trace	trace	0.1	0.6	trace	—	0.1
Rye, *Secale cereale*		trace	trace	0.3	trace	0.2	—	0.1
Tubers, unclassified		—	—	—	trace	0.1	—	0.1
Navy bean, *Phaseolus vulgaris*		—	—	0.3	—	—	—	0.1
Nimblewill, *Muhlenbergia* sp.		—	0.5	trace	—	—	—	0.1
Annual sunflower, *Helianthus annuus*		0.1	trace	0.2	trace	trace	—	0.1
Manure		—	—	0.1	—	0.3	0.3	0.1
Pea, *Pisum sativum*		—	—	—	0.3	0.2	—	0.1
Sudan grass, *Sorgum vulgare sudanense*		—	0.4	—	—	—	—	0.1
Chufa, *Cyperus esculentus*		—	—	trace	0.3	trace	—	0.1
Sunflowers, *Helianthus* sp.		trace	0.2	trace	trace	—	—	0.1
Ground cherry, *Physalis* sp.		0.1	—	0.1	trace	—	—	0.1
Short-horned grasshoppers, Acrididae		trace	trace	0.1	0.3	0.1	0.2	0.1
Crop Calcium-bearing Grit		0.1	0.1	0.1	0.1	0.1	trace	0.1
Gizzard Calcium-bearing Grit		0.3	0.1	0.1	0.1	0.2	0.3	0.2
Percentage of Total Diet		98.4	99.4	99.2	99.6	97.4	94.9	99.6
Total Food + Calcium-bearing Grit (Grams)		881.5	777.8	1431.0	719.1	503.1	101.1	4413.6

as for Missouri specimens: foods were identified, measured, and weighed; crop grit was checked with acid to determine calcium-bearing amounts; components of diet were calculated, using local and published chemical analyses of wildlife foods as a basis; and average grit consumption per bird was recorded by sex, month, and type.

Principal foods by month and sex comprise Tables 7 and 8. Only foods that comprised 0.1 per cent or more of the total diet were included, since "trace" amounts were deemed insignificant when calculating nutritional components.

The principal foods of all midwestern pheasants consist largely of seeds, leaves and fruit of domestic crops, including: corn, wheat, barley, soybeans, oats, cane, flax, proso millet, rye, alfalfa, rice, clovers, sudan grass, buckwheat, navy bean, pea, and apple. Amounts of these foods as percentages of the total monthly diet by weight, January-June, for male birds were: 89.6, 84.5, 85.6, 81.8, 96.2, and 93.6, for a six month average of 88.0 per cent. Comparable percentages for female pheasants were: 90.2, 95.0, 72.8, 87.7, 76.7, and 82.0, for a six month average of 83.8 per cent.

Few native foods were highly important to pheasants on a monthly basis. Summer cypress, *Kochia scoparia,* rated high in the female diet during March, while dayflower, *Commelina communis,* utilization by male birds in Missouri was high from January through April. Other native foods that exceeded 1.0 per cent, by weight, in male or female diets for one or more months included: wild oats, *Avena fatua,* Japanese rose, *Rosa multiflora,* sunflowers, Helianthus sp., green leaf material, yellow foxtail, *Setaria glauca,* Ellisia, *Ellisia nyctelea,* burcucumber, *Sicyos angulatus,* Russian olive, *Elaeagnus angustifolia,* water smartweed, *Polygonum punctatum,* nannyberry, *Viburnum Lentago,* bindweed, *Polygonum convolvulus,* wheatgrass, *Agropyron* sp., burdock, *Arctium minus,* green grass, pin-oak acorn, *Quercus palustris,* wild cucumber, *Echinocystis lobata,* and goosefoot, *Chenopodium* sp. In most instances these foods amounted to less than 2.0 per cent each of the total monthly diet, and comprised considerably less than 1.0 per cent of the six months food consumption.

Chemical composition of the average diets of wild midwestern pheasants was calculated for each month, by sex. The basis for determining composition of individual items included many sources of information (Table 2). The results comprise Table 9. Data are based upon 94.6 to 99.0 per cent complete diets for males, and 95.7 to 99.3 per cent complete diets for females, all of which are adjusted to make up total diets of the tested components. The many remaining foods that made up the one to five per cent amounts of total diets probably would not materially affect component percentages as shown.

TABLE 8: PRINCIPAL FOODS OF 555 MIDWESTERN FEMALE PHEASANTS, JANUARY–JUNE, 1959–1963
(Figures are percentages, by weight)

Food Item / Month: / No. Samples:	Jan. 73	Feb. 85	Mar. 115	Apr. 128	May 109	June 45	All 555
Corn, *Zea Mays*	65.9	60.1	36.0	60.8	55.9	45.9	53.2
Barley, *Hordeum vulgare*	1.2	8.4	14.2	0.7	4.0	4.2	8.0
Wheat, *Triticum aestivum*	2.8	13.5	6.6	11.1	7.1	9.9	7.4
Soybeans, *Glycine max*	10.3	2.2	5.1	6.4	6.6	4.3	5.6
Summer cypress, *Kochia scoparia*	0.8	2.3	14.3	trace	—	—	4.5
Oats, *Avena sativa*	2.3	7.5	4.8	2.2	2.0	1.0	4.1
Proso millet, *Panicum miliaceum*	2.0	trace	2.5	3.5	—	5.9	1.8
Rye, *Secale cereale*	3.2	1.4	0.7	0.1	0.3	0.5	1.1
Cane, *Sorgum vulgare*	0.1	1.1	0.8	1.3	0.4	—	0.8
Dayflower, *Commelina communis*	0.1	0.1	—	0.1	3.9	—	0.7
Russian olive, *Elaeagnus angustifolia*	trace	trace	2.1	—	—	—	0.6
Green leaf material	0.1	0.1	0.2	1.4	1.6	0.7	0.6
Wild oats, *Avena fatua*	trace	0.1	1.3	0.1	0.2	3.1	0.6
Japanese rose, *Rosa multiflora*	3.7	—	—	—	—	—	0.5
Flax, *Linum usitatissimum*	2.1	0.2	0.6	—	0.1	—	0.5
Wheatgrass, *Agropyron* sp.	trace	trace	1.8	—	—	—	0.5
Alfalfa, *Medicago sativa*	trace	trace	1.1	trace	0.3	—	0.4
Green grass	0.3	0.1	0.6	0.5	0.3	0.1	0.4
Sunflowers, *Helianthus* sp.	trace	trace	0.7	1.1	trace	—	0.3
Annual sunflower, *Helianthus annuus*	0.2	trace	1.1	0.1	—	—	0.3
Rice, *Oryza sativa*	—	—	—	—	—	7.0	0.3
Green foxtail, *Setaria viridis*	trace	trace	0.9	0.4	trace	trace	0.3
Yellow foxtail, *Setaria glauca*	0.3	trace	0.1	1.4	trace	trace	0.3
Aster, *Aster ? pilosus*	0.6	0.1	0.4	—	—	—	0.2
Sudan grass, *Sorgum vulgare sudanense*	trace	trace	—	1.3	—	—	0.2
Roses, *Rosa* sp.	0.1	0.1	0.3	0.3	—	—	0.2
Clover, *Trifolium* sp.	trace	0.1	trace	0.2	trace	3.3	0.2
Navy bean, *Phaseolus vulgaris*	—	0.5	trace	—	—	—	0.1
Chickweed, *Stellaria media*	—	—	—	—	0.8	—	0.1
Apple, *Pyrus Malus*	—	—	0.4	trace	—	—	0.1
Common ragweed, *Ambrosia artemisiifolia*	0.3	0.1	trace	0.4	trace	trace	0.1
Black locust, *Robinia Pseudo-Acacia*	—	0.5	—	—	—	—	0.1
False buckwheat, *Polygonum scandens*	0.6	trace	trace	trace	trace	—	0.1
Pinkweed, *Polygonum pensylvanicum*	0.3	trace	0.1	0.3	trace	trace	0.1
Bindweed, *Polygonum convolvulus*	0.1	trace	0.2	0.1	0.1	—	0.1
Coralberry, *Symphoricarpos orbiculatus*	trace	0.1	0.3	trace	—	—	0.1
Yellow rocket, *Barbarea vulgaris*	—	trace	0.4	—	—	—	0.1
Manure	—	—	—	—	0.6	—	0.1
Russian thistle, *Salsola Kali*	—	trace	0.3	trace	trace	—	0.1
Lady's-thumb, *Polygonum Persicaria*	0.6	trace	trace	—	trace	—	0.1
Bur-cucumber, *Sicyos angulatus*	trace	0.1	0.1	0.1	—	—	0.1
Osage orange, *Maclura pomifera*	—	—	0.2	0.2	—	—	0.1
Loosestrife, *Lysimachia thyrsiflora*	—	—	—	—	—	1.2	0.1
Buttercup, *Ranunculus abortivus*							trace
Dandelion, *Taraxacum officinale*							trace
Amber snails, *Succinea* sp.	trace	—	—	0.1	1.2	0.7	0.2
Short-horned grasshoppers, *Acrididae*	trace	trace	0.1	0.7	0.2	1.0	0.2
Caterpillars, Lepidoptera	0.1	trace	0.2	0.5	0.2	0.5	0.2
Snails, unclassified, Gastropoda	—	trace	—	0.3	0.7	trace	0.1
Earthworm, *Lumbricus* sp.	—	—	—	0.1	0.8	trace	0.1
Amber snails, *Succinea avara*	—	—	—	—	0.7	0.1	0.1
Eggshell (? *pheasant*)	—	—	—	trace	0.5	0.2	0.1
Snail, *Anguispiar alternata*	—	—	—	—	0.6	—	0.1
Ants, Formicidae	trace	trace	trace	trace	trace	1.5	0.1
Snail, *Lymnaea palustris*	—	—	—	0.1	0.3	—	0.1
Snail, *Lymnaea* sp.	—	—	trace	0.2	0.2	trace	0.1
Insect larvae and unclassified, Insecta	trace	trace	—	0.1	0.2	0.1	0.1
Crop Calcium-bearing Grit	0.1	0.2	0.2	0.4	2.1	0.5	0.5
Gizzard Calcium-bearing Grit	0.2	0.4	0.3	1.9	4.8	3.8	1.4
Gizzard snails and clams	—	—	—	0.1	0.4	trace	0.2
Percentage of Total Diet	98.4	99.3	99.0	98.6	97.1	95.5	98.8
Total Food + Calcium-bearing Grit (Grams)	716.7	1139.5	1330.3	716.2	790.1	213.3	4905.9

Data on composition of specific animal foods were not always available, so certain groups were combined for the purpose of approximating composition. Typical of combinations were beetles, all kinds of which were considered as a unit, and miscellaneous insects which included true bugs, flies, wasps, as well as spiders, centipedes, millipedes, sowbugs, and other types. All snail components were based upon the chemical analyses of whole, live tadpole snails, *Physa* sp., collected in central Missouri, since these are similar in size and conformation to the amber snails, *Succinea* sp., that were prominent in the pheasant diet. Central Missouri limestone with a calcium content of 37.68 per cent was used for approximating amounts of calcium in all calcium-bearing grit.

Analyses for male birds (Table 9) show no major changes in diet from month to month. The protein fraction ranges between 12.53 and 12.76 per cent during the six months. Fat levels range from 3.64 to 4.63 per cent, with the higher amounts during the coldest months. Carbohydrates (NFE) range from 63.21 to 65.45 per cent. Calcium levels are consistently low, as .23 to .38 per cent of the monthly diets. Phosphorus levels also are low.

In contrast, female pheasant diets show marked change, particularly as regards the mineral components. Protein levels rank generally higher than for male birds, with a range of 12.42 to 14.57 per cent. Fat levels vary from a high of 5.60 in March to a low of 3.82 per cent in June. Carbohydrates are correspondingly lower than for male birds and range from an April low of 54.73 to the February high of 64.99 per cent. As compared to male birds, the female diets show somewhat greater amounts of calcium in the diet during February and March—six times as much as male diets in April, 14 times as much in May, and 10 times as much in June. These differences appear

TABLE 9: PROXIMATE ANALYSES OF MIDWESTERN PHEASANT DIETS, BY MONTH, AND SEX

Month	No. Samples	Moisture	Protein	Fat	NFE	Fiber	Ash	Ca	P
Males:									
January	56	12.51	12.72	4.63	63.21	4.11	2.43	.378	.269
February	67	12.38	12.62	4.61	63.59	4.35	2.19	.261	.270
March	107	11.98	12.59	4.15	64.06	4.55	2.57	.242	.280
April	105	12.20	12.76	3.64	64.86	3.93	2.42	.235	.294
May	74	12.66	12.55	4.04	65.45	3.12	1.85	.327	.276
June	33	11.50	12.53	3.99	65.40	4.08	2.29	.268	.305
All Months	442	12.23	12.59	4.19	64.11	4.19	2.41	.291	.277
Females:									
January	73	11.68	14.03	5.35	61.76	4.54	2.27	.324	.302
February	85	12.03	12.42	3.89	64.99	4.06	2.00	.364	.295
March	115	11.13	14.26	5.60	58.53	6.72	3.21	.413	.336
April	128	11.51	12.99	4.67	59.90	4.67	2.91	1.436	.307
May	109	10.63	13.33	3.91	54.73	3.32	5.96	4.589	.285
June	45	10.82	14.57	3.82	57.46	5.40	3.31	2.714	.367
All Months	555	11.41	13.57	4.61	60.14	4.91	3.23	1.249	.311

highly significant and stem principally from increased consumption of snails and calcareous grit by female pheasants during the reproductive season. Phosphorus amounts are consistently low and only slightly exceed those for male birds.

The composition of an average diet possibly does not present a true proportion for each component. The samples were collected from the better pheasant ranges of the various states, but all birds collected during a calendar month were included as a group because the physiological status of any bird was not known.

It is my premise that the female pheasant undergoes a rather abrupt maintenance-to-production dietary change about the time that egg laying begins. The unusually large consumption of snails, other animal foods, eggshell, and calcium-bearing grit shows a selectivity for these foods. If the physiological status of each bird were known, and data were compiled only from hens in production, the dietary components undoubtedly would differ markedly from the general averages shown by this study. It is entirely conceivable that actively laying hens consume a greater amount of insects and snails than nonlaying hens, and consequently obtain much greater amounts of protein and calcium. Very meager data from Missouri birds whose physiological status was known show much greater snail consumption by hens in active laying condition than by those with a conspicuous brood patch, although use of calcium-bearing grit was greater in the brooding birds.

Data relative to sources and approximate amounts of calcium derived therefrom by midwestern pheasants comprise Table 10. The results show that male birds obtain more than one-half their calcium supply from plant sources, a small amount from insects, and the re-

TABLE 10: CALCIUM SOURCES IN MIDWESTERN PHEASANT DIETS, BY SEX, AND MONTH

Sex	Month	No. Samples	Percentage of calcium in diet from						
			Plants	Insects	Snails	Eggshell	Crop Grit	Gizzard Grit	Total
Males:									
	January	56	.227	trace	trace	0	.038	.113	.378
	February	67	.185	trace	trace	0	.038	.038	.261
	March	107	.166	trace	trace	0	.038	.038	.242
	April	105	.158	.001	trace	0	.038	.038	.235
	May	74	.163	.051	trace	0	.038	.075	.327
	June	33	.129	.026	trace	0	trace	.113	.268
	All Months	442	.178	trace	trace	0	.038	.075	.291
Females:									
	January	73	.187	.024	trace	0	.038	.075	.324
	February	85	.138	trace	trace	0	.075	.151	.364
	March	115	.204	.021	trace	0	.075	.113	.413
	April	128	.166	.119	.284	trace	.151	.716	1.436
	May	109	.338	.101	1.354	.196	.791	1.809	4.589
	June	45	.256	.514	.246	.078	.188	1.432	2.714
	All Months	555	.189	.059	.246	.039	.188	.528	1.249

mainder from grit. Female pheasants in contrast obtain substantial amounts from insects, snails, eggshell, and grit, in addition to that obtained from plant sources.

Dalke (1938) reported that in Michigan the yearly average amount of grit per bird was 3.39 grams. He noted an increase in gravel content during the breeding months, and found as much as 10 grams of gravel in the gizzards of laying hens. Average size of gravel was 6.0 millimeters diameter, with 18.3 millimeters the largest.

In this study average total grit per male bird (3.96 grams) varied little from January to June. Calcium-bearing grit was found in very small amounts at all times, with greatest amount in January (0.07 grams) and a decline thereafter. The average total grit from female birds was 4.33 grams per bird, but varied from a high of 5.13 grams in May, 5.00 grams in March, and lows of 3.53 and 3.68 grams in January and June, respectively. Calcium-bearing grit in females was minor during the first three months, reached a peak of 0.50 grams in May, and declined to 0.20 grams in June. These data again show that hen pheasants seek and consume much greater amounts of calcium-rich grit during the production period. Missouri birds utilized crushed limestone from road surfacing or field applications during this period, while birds from other areas largely supplied their needs from the calcium-rich glacial gravel available naturally in the more northern states.

DISCUSSION AND RECOMMENDATIONS

It has been more than three decades since Leopold (1931) theorized that simple or complex nutritional factors might account for the interrupted distribution of pheasants in the central United States. Serious efforts to confirm or disprove this theory have been few. Leopold's "glaciation hypothesis" is based largely upon the fact that certain minerals, particularly calcium, might be an element supplied by glacial gravel that is less available in non-glaciated areas. An important objective of this study was to learn the sources and amounts of calcium in the diets of wild midwestern pheasants. Other studies on the subject have dealt with the requirements for penned birds and agreement appears to have been reached on pheasant needs for calcium.

The calcium requirement of 1.2 per cent of the diet of penned pheasants, as determined by Dale and DeWitt (1958), and Scott, Holm, and Reynolds (1958) were discussed previously. Greeley (1962), in Illinois, fed hen pheasants levels of calcium ranging from 0.37 to 2.34 per cent of the diet during the breeding season. Reduction of the rate of egg production, the amount of ash in the leg-bones, and in the thickness of eggshells were observed at 1.09 per cent, and less, of calcium in the diet. He also found that bone-ash content and eggshell thickness of wild hens from thriving populations in central Illinois were equivalent to those found in the experimental hens with two per cent, or more, of calcium in their diets. Harper (1963) reported a relationship between calcitic grit consumption and age of young pheasants in Illinois. Until recently, with rare exceptions (Dalke, 1935, 1938; McCann, 1939), little credence has been given to the birds' ability to select required components of diet. The results of the present study provide definite proof that wild pheasants are capable of selecting foods, when available, to satisfy their physiological needs.

Study results have shown that pheasant hens in occupied range of Missouri receive adequate calcium with demonstrated amounts of 2.33 per cent in April when active nesting occurs, 1.35 per cent in May, and 1.33 per cent in June during brooding and renesting. Peak calcium intake occurred later farther north, as shown by the nine-state study, and reached greater proportions with demonstrated amounts of 1.44 per cent in April, 4.59 per cent in May, and 2.71 per cent in June. These findings support the indicated feeding pattern of pheasants in Missouri and show the same general trend throughout the occupied midwestern range.

Snails often are heavily utilized to supplement grit. The crop of one bird contained 540 amber snails, *Succinea* sp., amounting to 16 cubic centimeters. Other samples contained 9.4, 7.5 cubic centimeters and smaller amounts. Thus, it would seem that snails often may be used in lieu of calcareous grit in areas where the availability of the latter is limited.

Since limited data from Missouri pheasants were confirmed by extensive data from eight additional midwestern states, it became desirable to know whether snails and calcareous grit were generally available throughout north-central Missouri where pheasants have failed to establish a population.

A planned route through 15 north-central Missouri counties was followed from the vicinity of Brookfield, west to St. Joseph, north to Maryville, east to Hurdland, and southward to Clarence during May, 1963. Stops were made at selected approximate 10-mile intervals where five searches of approximately one square foot each were made for snails. Location of search varied with vegetative cover and conditions, but included weed-covered bottomland, leaves and duff, loose bark on logs, underside of logs, railroad embankments and rights-of-way, vegetated levees, upland hedgerows, highway embankments, woodlots, fencerows, abandoned roadways, odd-corner wasteland, and ditch bank cover. A total of 185 samples taken at 37 stops showed the following results from careful but not meticulous examination of the sample sites. Snails of 20 identified kinds were collected from 70 (37.8 per cent) of the sample locations. Success in finding snails was attained at 28 (75.7 per cent) of the 37 stops. A total of 380 snails were collected, which amounted to 10 snails per stop of five samples, or 2.05 snails per sample examined. In view of these results it was concluded that in these areas snails are generally available in sufficient numbers so as not to be a limiting factor in pheasant nutrition.

Information published by the Bureau of Public Roads, U. S. Chamber of Commerce, December 31, 1961, shows a total of 10,030.7 miles of county roads in the 15 north-central counties, of which 6,639.6 (66.2 per cent) are stone or gravel covered. An additional 51.7 miles (0.5 per cent) have low-type bituminous surface. Creek or river gravel is generally unavailable and unused for road surfacing in north-central Missouri, so quarried and crushed limestone accounts for the vast majority of surfacing materials. Crushed limestone also is used in the bituminous mix and some remains available to pheasants along the borders of such roads. Thus crushed limestone is readily available on two-thirds of the county roads which grid each county at one to two mile intervals.

A further check along a 50-mile route through Knox, Shelby, and Monroe counties in northeastern Missouri showed that of 76 county roads observed 70 (92 per cent) were surfaced with crushed limestone, while the remaining 6 (8 per cent) were graded earth. Crossroads in this survey were classed as two observations, one each way, while T-junctions classed as a single observation.

Soil enrichment through use of fertilizer and agricultural limestone is common in modern farming. Agricultural Stabilization and Conservation statistics for 1958 show payments made for application of crushed limestone on 15.6 per cent of all farmland, and 25.1 per cent of all cropland in the 15-county north-central area. Approximately one-fifth of all farmers participate in the ASC program. Many additional acres are known to be treated by the remaining four-fifths of all farmers who do not participate in the government sponsored cost-sharing programs, so that considerably more than the indicated one-fourth of all cropland receives annual treatment.

These findings make untenable the "glaciation hypothesis" as far as calcium is concerned, as applied now to northern Missouri where calcium-rich food sources are readily available to pheasants. Such may not have been the case, however, when pheasant stocking was practiced some 30 to 50 years ago, prior to road improvement and government subsidized soil enrichment and conservation programs which began after attempts to establish pheasants had failed often enough not to be repeated. If the glaciation hypothesis (again, as regards calcium) had merit then, pheasant stocking today might achieve success where former attempts failed.

The results of this study show that availability of calcium is not the limiting factor to pheasant distribution in Missouri. Neither do insufficient protein, fat, carbohydrate, or fiber appear as critical components of diet, since pheasants are capable of fulfilling requirements through selective feeding. Phosphorus levels were not critically studied, since grit was not analyzed for this element. Plant and animal foods supply approximately one-half of the required amount. Trace elements were not within the scope of this investigation.

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DISCUSSION

DISCUSSION LEADER WELDON ROBINSON: Thank you.

Leroy, do you feel that tabulations of data based upon more specific physiological status of the birds would affect results? For example, if you had nesting data only for nesting hens rather than for all hens in the area, how would that affect your findings?

MR. KORSCHGEN: I have very definite feelings but very little data on the subject. Most of these birds came with unknown status, They were of all types. I definitely feel that there is an upsurge here at some time, probably about the beginning of nesting. If I had been able to tabulate only hens that were laying or perhaps brooding, just during the nesting period, I think these figures as indicated, the

4.59%, would have been much higher. I also feel that the protein fraction would possibly have come up to the 25% or so that pen studies show is required.

MR. DOUGLAS GILBERT (Colorado State University, Fort Collins, Colorado): In your paper you have discussed only the protein, calcium and phorphorous. Have you made a complete analysis, and if so, will it appear in your published paper?

MR. KORSCHGEN: Yes. A complete proximate analysis as usually given—moisture, protein, fat, carbohydrate, fibre, ash, calcium and phosphorus. All of those will appear in the published paper. I cut it here so I could get the most pertinent information on the slides, since there was not going to be time to discuss all of it.

DR. FRED GREELEY (Massachusetts): Referring to your first question, I think we have a little data in Illinois, where we did select hens that were known to have been laying on the records, and we knew what stage these hens were in.

Those birds showed no decline in bone ash, even though they had been living outside of the pheasant range for a period of two to five months.

MR. KORSCHGEN: Thank you, Fred. I was aware of that paper but I hadn't seen it in published form, so I didn't refer to it. I believe I have made a reference to it later in my published paper.

MR. ROBINSON: Any more questions?

Aside from your technical data, I think your findings that pheasants are so dependent upon agricultural crops is a good example of why populations of certain birds and mammals have changed as land use has changed.

LOUSE AND CHIGGER INFESTATIONS AS RELATED TO HOST SIZE AND HOME RANGES OF SMALL MAMMALS[1]

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Despite various solutions of the problem of standing or clinging room by ectoparasites, such as conversion of energy, adjustment of shape or reduction in size, ectoparasites are limited in number on hosts by the amount of infestable area, divided by the amount of space which each individual requires between itself and its neighbors. Large species may bear Anoplura and Mallophaga (Hopkins 1949) and small species bear no lice whatsoever.

Two general types of parasites exhibit this rule (the relation of infestations to available space): those which, like chiggers (Trombiculidae), lie in wait for the host in its general habitat and those which, like lice (Anoplura and Mallophaga), live permanently on their hosts and attain maximum population by breeding thereon. These factors will be examined below for lice: *Polyplax abscisa* and possibly *Hoplopleura acanthopus* on California meadow mice, *Microtus californicus; Hoplopleura hesperomydis* on harvest mice, *Reithrodontomys megalotis,* and deer mice, *Peromyscus maniculatus*; and for chiggers: *Euschoengastia radfordi, Neotrombicula dinhartae, N. jewetti, E. peromysci* and *E. belkini* on the three species of hosts.

[1]This investigation was supported in part by a research grant (E-3653) from the National Institutes of Health, Division of Research Grants, Public Health Service.

(*E. pomerantzi* and *E. lacerta* also were found, but on only four host individuals.)

Further relations between host size and parasite population are explored, primarily by the senior author, from examples in literature.

ACKNOWLEDGMENTS

Thanks go to Professor Deane P. Furman, Division of Parasitology, for reading this manuscript and for benefit of his experience and to Dr. Richard B. Loomis for identification of the chiggers.

LOCATION AND PROCEDURE

The field aspects of this study were conducted in San Mateo County, California, immediately south of San Francisco. We searched 127 meadow mice, 39 deer mice and 31 harvest mice for lice in a laboratory after having killed and preserved the hosts by embalming dry (Mohr, 1959). Data from meadow mice were handled in two groups: those for individuals which were 10 cm long or longer, and those less than 10 cm long. This permitted us to divide the lot into two groups of about equal numbers. Mice were searched for chiggers both in the laboratory and in the field.

Since the percentage of mice infested is readily determined, this, rather than the average number of parasites, is emphasized here.

Observations on home ranges of the mice were based on live-trapping at 10-foot intervals, marking by use of ear tags and releasing, then reobserving them by retrapping over a period of two years (1961 and 1962). (No single mouse lived more than about a year.) The traps were set in lines 20 feet apart during part of one day and the succeeding night, then moved to the interspaces during the next day and examined the next morning. Trapping was done during three or four days per week during 91 weeks beginning in February 1961 and ending in December 1962. Capture sites for each mouse were recorded on maps. Traplines were walked north-south and east-west in alternate examinations.

Approximations of the area traversed by the mice were made in two ways: (1) average distances between successive trap stations in which each mouse was caught were determined following the approximation used by Spencer and Davis (1950), and (2) average individual (home) ranges were determined by a modification of the composite home-range method used by Stumpf and Mohr (1962) except that in the present paper, median center and axes are used rather than mean centers. These are less influenced by distant points visited.

Since shapes of ranges of a given species tended to be similar but to be mirror images or nearly mirror images of one another, they

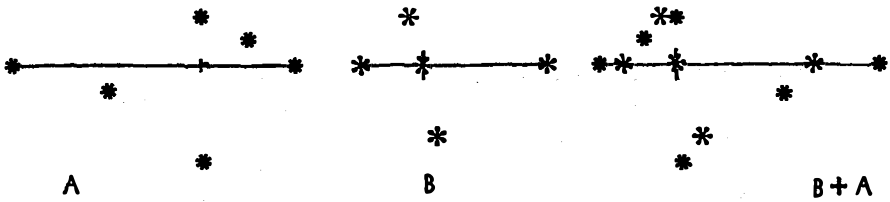

Fig. 1. Distribution of observations in two home ranges of meadow mice. Symbols in A and B represent points at which each individual was trapped. "A" represents a dextral range and "B" a sinistral one. "B + A" represents composite range with equivalent axes and centers fitted one over the other.

were fitted as in Figure 1 which shows two such home ranges, A and B, fitted to make a composite range for calculation of average shape and area. Forty-four per cent of the ranges were interpreted as being dextral (Fig. 1, A) and 46 per cent as sinistral (Fig. 1, B) with respect to each other. Frequency distributions and 3 point moving averages were used to determine lengths and widths of ranges (Fig. 2). Others only needed to be rotated 180° to fit.

Since chiggers were most abundant during the period from September through December, the breeding season of the mice, and since most of the small mice occurred from January to June when the chiggers were scarce, the data on infestation were treated in two groups: one during the optimal chigger season and one during the period of low chigger population.

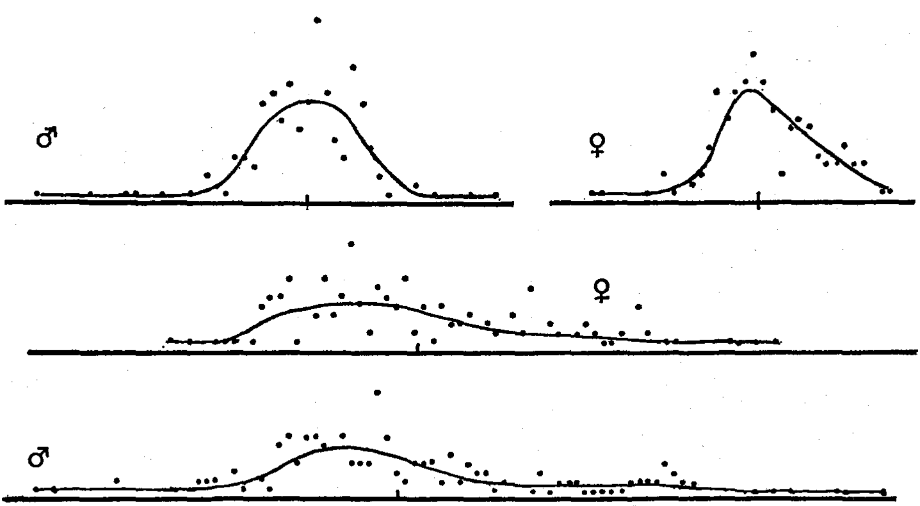

Fig. 2. Side view and end view of frequency distribution of observations in composite home range of meadow mouse, used to calculate proportions of observed home areas.

Aspects of this study pertaining to lice consist of an evaluation of the relation of presence or absence of lice on large and small species of rodents. Although species of lice tend to evolve into small, or narrow, or sedentary forms to survive decreasing size of their host species, many appear not to adapt quickly enough.

RESULTS

Infestation as Related to Host Size

The Lice: Thirty eight per cent of the 127 meadow mice examined by us in the laboratory were found to be infested by lice. Fifty five per cent of the 56 large ones but only 23 per cent of the 71 small ones were infested.

Three of the harvest mice but none of the deer mice were found to be infested.

About an equal number of meadow mice which were searched in the field yielded some lice but, since the percentage of infestation observed in the field was as, as expected, slightly lower than that of animals searched in the laboratory, no further use is made of the field data. No lice were found on harvest and deer mice examined in the field.

There appears to be no difference in percentages of male and female meadow mice infested unless they are sorted out according to size: 45 and 42 per cent respectively were observed to be infested based on 83 females and 44 males in the laboratory sample.

As expected, there was no difference in infestation by lice related to size of home range of the hosts, but large males bore lice more frequently than did large females.

The Chiggers: Meadow mice which were 10 cm. or longer were more frequently infested by chiggers than were shorter ones. During the season when chiggers were most numerous 59 per cent of the longer mice were infested as compared to 39 per cent of the smaller ones, and during the season of chigger scarcity 66 per cent of the longer mice were infested as compared to 21 per cent of the smaller ones (Table 2).

Infestation as Related to Area of Host's Home Range and Distances Between Catches

Percentage of Hosts Infested by *Chiggers*: The percentage of meadow mice infested by chiggers was positively related to average distances between traps in which the individuals were caught successively (Table 1). During the optimal chigger season, 50 per cent of those mice which were caught in traps 15 feet or less from where

TABLE I: PERCENTAGES OF MEADOW MICE INFESTED BY CHIGGERS BY HOST SIZE SEASON, AND DISTANCE OF TRAVEL

Based on Length of Mouse	September through December		January through August		Gross and totals	
	Percent Infested	Number of Mice in Sample	Percent Infested	Number of Mice in Sample	Percent Infested	Number of Mice in Sample
70–99 mm.	39	76	21	265	26	341
100–138 mm.	59	231	66	92	60	323
Based on Distance Between Traps						
0–15 ft.	50	184	12	239	29	424
20–70 ft.	58	130	18	140	37	270

they were caught the previous time were infested whereas 58 per cent of those caught at greater distances were infested. When chigger populations were low, only 12 per cent of those caught at lesser distances were infested compared to 18 per cent of those at greater distances. Therefore about 1.3 times as many of those caught at the greater distance were infested as compared to those caught at the lesser distance.

The average distance between successive points of capture was 21 feet for males and 17 feet for females. This may not represent the actual distance of travel; traps which are near the host's center of activity, or centers of activity, are thought to suppress travel; hence the observed size of the home range. Nevertheless some of the individual's natural tendency expresses itself in a positive difference in distance between traps in which it is caught.

We have too few records to provide statistically significant interpretation of the influence of distance within the large and small mice. Among our 341 mice less than 10 cm. long, caught successively

TABLE 2: SIZES AND SHAPES OF HOME AREA ENCOMPASSING 67 AND 90 PERCENT OF OBSERVATIONS IN AVERAGE HOME RANGES OF MEADOW MICE, BY NUMBER OF OBSERVATIONS PER MOUSE.

Number of Observations of Individual	AVERAGE HOME RANGE: For 67 Percent of Observations		AVERAGE HOME RANGE: For 90 Percent of Observations		Number of Ranges Observed in Class
	Proportions 1X:	Length (in feet)	Proportions 1X:	Length (in feet)	
MALES					
3	3.0	65	2.1	72	26
4 & 5	3.3	105	3.6	154	18
6 thru 8	2.0	40	1.4	80	16
9 thru 12	2.5	120	2.0	137	6
FEMALES					
3	4.1	80	4.6	133	15
4 & 5	2.9	60	3.4	110	42
6 thru 8	3.4	64	2.6	134	18

in traps 10 feet apart, 29 per cent were infested by chiggers as against 26 per cent for those caught from 20 to 30 feet apart. Of the 323 larger mice which were caught 20 to 30 feet apart, 34 per cent were infested as against 39 per cent caught from 40 to 70 feet apart. Based purely on a difference in average width, or length, of mouse one might expect 1.2 times as many large as small mice infested or, say, from 31 to 35 percent of the large mice, provided the chiggers are randomly distributed.

Home ranges represent the areas within which travel of the individual hosts between traps is confined. Ninety per cent of the trap stations or points at which the average male was observed lay in an area of approximately 0.04 acres. This was 1.6 times as large as that of average female ranges.

Sixty seven percent of the points were in areas averaging about ⅓ as large.

The ranges of most males tend to overlap those of two or more females, thus making for at least triple exchange and maintenance of populations of chiggers.

Absolute Number of Chiggers: The number of chiggers per infested host tends to parallel the percentages infested but depends on the degree of dispersal of chiggers in the general habitat. The following data show the relation by months for all chigger species, beginning in July and ending in May. Percentages infested were as follows: 1.0, 83, 90, 98, 100, 97, 86, 74, 58, 29, 0.01. The highest percentage of mice was infested in November. The mean numbers of chiggers per infested mouse for the same months was: 1.5, 4.0, 7.0, 5.0, 26+, 35+, 10, 3.0, 1.3, 1.4, 1.0. The highest means occurred in November and December.

The means and percentage are closely related until 100 percent of the hosts are infested and depend on species and habitat, but the mean load of chiggers may continue upward after 100 per cent of the hosts are infested. Investigators commonly combine the mean per infested host with the percentage infested to make a single mean or "index" for all hosts examined in a given size, sex, time period or other condition.

DISCUSSION OF FIELD DATA

Relation of Host's Size and Home Range to Infestation

The Chiggers: The percentage of hosts infested by chiggers is influenced measurably by the host's size and size of its home range. It also is affected by distribution of the chiggers in the host's habitat, the host's structure and physiology, amount of cleansing ability, kind and intensity of use of various parts of the habitat, time of daily activity as related to activity of the parasite, and weights of the hosts. Usually the larger hosts have the larger home ranges but this varies between host species and individuals.

In one comparison between parasitism by chiggers on the small Polynesian rat, *Rattus exulans manoquarius,* and another, *R. ruber sansapor,* which has an average surface area about 3.5 times larger, the larger species averaged about 40 times as many as the smaller even though the hosts were taken in the same habitat (Mohr, 1961:979). The smaller rats attained an average of about 430 chiggers per rat in ideal chigger habitat (Mohr, 1956:387) and the larger could have accumulated many more, say 1,500 per rat based on size of equivalent infestible host surface only. (This does not take into account fine differences in shape or susceptibility).

Although the numbers of the two host species examined from the same habitat (26 and 11) are small, the relative infestation (1 to 40) as compared to the relative capacities (1 to 3.5) indicates the extent to which other factors than amount of infestible surface were operating to increase infestations on the larger rat. Difference in other characteristics of the rats and observational error must account for the difference (1 to 40) between the observed infestation in the habitat in which both were taken together and the difference (1 to 16) expected from the relative sizes of hosts plus areas of their home ranges. It should be noted here that the circular method of calculating home ranges which was used in that study is unrealistic absolutely, but of some use comparatively for species which have home ranges of similar shapes. Both species of rat have narrow ranges.

Only 84 percent of the smaller rats were infested as compared to 100 per cent of the larger. For each increment of 1 cm. in length between these two species, an increment of 1.2 percentage points was infested. For each increment of 1 sq. cm. difference in area between the two rats, an increment of 2.7 percentage points was infested.

In the meadow mice examined by us, the morphological, and possibly the physiologic and behavioral differences in the size groups presumably are less than between the two species of *Rattus*. Adult California meadow mice are about as large as adult Polynesian rats; at 10 cm. length, the mice attain adult appearance and at about 10.5 cm. the rats do so. Large individuals of both attain lengths of 13.8 cm. Since we are dealing with somewhat differently proportioned hosts and different species of chiggers, climates, habitats, and home-range sizes, a difference in level of infestation is to be expected.

For each increment of 1 cm. in length of the meadow mice during the season of greatest chigger abundance, there was an increment of 6.1 percentage points infested, and for each increment in length during the season of low population an increment of 16 percentage points was infested. This difference was partially the result of the increased exposure of the larger rats as they traveled over larger ranges, hence is expecially evident as the chigger population declined during the off season.

The Lice: There was no apparent direct relationship between the percentage of meadow mice infested by lice and the areas of their host's home ranges. For each increment of 1 cm. in length of host there was a simple increment of 10 percent infested.

However, 52 percent of 29 male mice and 38 percent of 58 female mice over 10 cm. long were infested. Mice smaller than 10 cm. showed no difference. Based on 1,218 examinations in the field, indications are that the difference of percentage infested was greater for the large mice but the field examinations are only suggestive.

Regression lines based on index figures by Cole and Koepke (1952:30) for three species of rat (*Rattus norvegicus, R. rattus* and *R. exulans hawaiiensis*) indicate a straight line relationship between the size of rat and the percentage infested by lice. The regression line for each pair ends at 0. However, a regression line based on our microtine data suggests that smaller percentages of the smaller mice would bear lice and the point at which no lice might survive must occur well above 0 cm. The smallest mammals might not support lice at all or might bear them infrequently, even if they were otherwise as congenial a habitat as *Microtus* seems to be. (High percentages of most *Microtus* are infested.)

The regression line of *Microtus,* based on our data, suggest that only about 16 percent of any species of similar hosts as short as 6.0 cm. might bear known species of lice. (Here readers may find it convenient to keep in mind that feral house mice are about 7.0 cm. long.)

Actually the smallest microtine mouse of North America, *M. mexicanus* (8.0-10 cm.) is not yet reported to bear lice. The smallest reported infested in any country are *Clethrionomys glareolus* (Elton et al. 1931) and members of the genus *Pitymys: P. pinetorum* (8.4-12 cm. according to Burt and Grossenheider, 1951); *P. savii* (8.9-10); and *P. subterraneus* (7.4-10 according to van den Brink, 1955). All of the larger species of meadow mice in America, Europe and Asia are infested: *M. arvalis, M. californicus, M. nivalis, M. mordax, M. pennsylvanicus* (Ferris, 1951), *M. hirtus* = *M. agrestis* (Elton et al., 1931); *M. ochrogaster* (Jameson, 1947:141); and *M. montebilli* of Japan (Suyemoto et al., 1954). Possibly even the smallest known microtine may eventually be found infested but it is suggested that decreasing percentages of the smaller ones will bear lice.

Relation of Presence or Absence of Lice to Host Size in Other Host Groups

A review of studies of other groups of animals reveals similar relations between size of host and presence or absence of Anoplura and Mallophaga. Those with a considerable number of mouse-like or rat-like members will be discussed first.

The house mouse, *Mus musculus,* is credited by Ferris (1951: 299) with being host to three species of lice: *Hoplopleura acanthopus, H. hesperomydis* and *Polyplex serrata.* Johnson (1951:299, 1960:25) suggested that Ferris' record of *H. hesperomydis* was based on misidentification of *H. capitosa* then an unknown species. The other two species are known to be dependent on Eurasian mice but to transfer to sylvan house mice on which they live successfully for shorter or longer periods. *P. serrata* also regularly occurs on laboratory mice everywhere, probably sustained by: 1) the larger size of the mice and, 2) by crowding of mice in cages, making for easy transfer.

Only *H. capitosa* is a primary parasite of feral house mice and only in the warmer regions of the Mediterranean. The small size of this host combined with other adverse factors, possibly cold and low humidity, reduce their louse infestations by attrition and they have not been found infested elsewhere.

During the course of a survey in Georgia, U.S.A., Morlan (1952: 83) found 7 percent of the house mice infested by *Polyelap spinulosa* whereas 67 percent each of the roof rats, *Rattus rattus,* and Norway rats, *R. norvegicus,* were infested. The percentages are based on examination of 520 mice, 21,489 roof rats, and 8,082 Norway rats in a bulk analysis over a period of four years. For each increment of 1 cm. of host, there was an increment of six percentage points in infestation, and the decremental point of the infestation line indicates that, when hosts of murine type decline to only 7.5 cm., populations of *Polyplax spinulosa* may have difficulty in maintaining themselves. The smallest murine mouse of Europe, *Micromys minutus* (5.8 to 7.6 cm.), bears two species of Anoplura. This falls somewhat below the terminus of the regression line for *Mus musculus.* There is no report known to us as to whether the two lice occur on single indviduals or on different individuals at different parts of the mouse's range.

The smallest known North American mouse, *Baiomys taylori* (5.1-6.4 cm.) apparently supports no lice; at least none is reported by Hopkins (1949), Menzies and Hightower (1951), or Ferris (1952).

Ferris reports lice from five species of *Peromyscus* measuring from 7.1 cm. (for *P. manculiatus*) to 12 cm. for *P. sitkenses,* (that is, rather large mice). Since Ferris was not interested in the relation of infestation to size of host species, he did not list the subspecies of the hosts; hence we cannot determine lengths as well as desired. Other investigators have, however, added details which suggest the dynamics of infestations. These suggest that presence and absence of lice on the smaller species, subspecies, and varieties declines as was indicated above for microtinae. Since *Hoplopleura hesperomydis* occurs on *Peromyscus* and *Reithrodontomys* we have a good size gradient. Bulk data of Morlan, 1952, suggest that cotton mice, *Peromyscus gossypinus* 8.9-12 cm.), may be more frequently infested than old field mice, *P. polionotus* (8.7-9.7). Five percent of the former (249 examined) but only a single individual of the latter, of which 245 were examined, bore *H. hesperomydis.* It is most probable that some lice were missed in the brushing examination but the relation between the infestations to size of host in these two vary similar mice is evident. Morlan found no lice at all on 86 eastern harvest mice *Reithrodontomys humulus humulus* (7.0-7.7 cm.) though the mice were caught during the same trapping period. Holdenreid, Evans, and Longanecker (1955 :14) found none on the western harvest mouse (5.6-7.7 cm.) but did find them on western deer mice, contrary to our experience. Cook and Beer (1955 :411) found 58 percent of the male and 25 percent of the female *Peromyscus maniculatus* infested in Minnesota in 1952 and 12 percent in 1953. They suggest (p. 412) that the deer mouse population might have outstripped the louse population in 1952 because of a remarkable increase in the mouse population.

Though the smaller harvest mice are commonly without lice, one species, *Reithrodontomys mexicanus* (7.1-8.8 cm.) is reported infested (by *Polyplax auricularis,* Ferris, 1951) and another *R. humulis,* by *H. hesperomydis,* 6.4-6.8 cm. (Verts, 1962). Verts examined 34 specimens and found only one louse.

We examined 226 western harvest mice in the San Francisco area over two years and found 10 lice on only three individuals whereas we found none on the western deer mice. However, Holdenreid, Evans and Longanecker (1951 :14) found *Hoplopleura hespermydis* on three *Peromyscus maniculatus* out of an unstated number examined. The low percentages infested as observed by us may indicate that the smaller harvest mice, which measure only from 5.9 to 7.1 cm., are at the lower limits of suitability to lice. *Reithrodontomys montanus* (5.9-7.1 cm.), *R. humulus* (6.4-7.1 cm.) and *R. megalotis* (6.4-8.7 cm.) are not recorded by Ferris as being infested though we should not be surprised if eventually low percentages will be found infested.

Although the California specimens of *Peromyscus maniculatus* were not found to support lice, Beer and Cook (1958) show this host to be infested by *H. hesperomydis* in western Oregon and in northern Minnesota (Cook and Beer, 1955 and 1958). Holdenreid, Evans and

Longenecker (1951) report the *P. californicus* (8.7-12 cm.) to be infested in California.

In an extensive investigation of the Florida deermouse, *P. floridanus,* (11 to 13 cm.), Layne (1963) found only one louse, a *Hoplopleura hirsuta,* on 574 mice. Since this louse undoubtedly was a straggler from its regular host, *Sigmodon hispidus,* indications are that the Florida deer mouse does not support lice despite its moderate size. Morlan (1952) found 13 *Peromyscus gossypinus* (8.9-12) by *H. hesperomydis* but found none on 86 *Reithrodontomys.*

Similar relations exist between host size and louse populations among the spiny pocket mice (Geomyoidea: Heteromyidae) of North America. Nine species which are not reported as infested vary in size from 5.1-5.4 cm. to 9.2-11 cm. with an average of 7.4 to 8.9 cm. Infested ones range from 7.7 to 13 cm. with an average of 9.2 to 10 cm. The known infested species are *P. californicus, P. formosus* and *P. hispidus.*

No lice are known to inhabit bats, many of which are smaller than house mice. Hopkins (1949) and Ferris (1951) suggest that this may be the result of competition with bat flies (Nycteribiidae and Streblidae) and parasitic mites. The small size of most common bats may be a contributing factor. Large bats such as "flying foxes" may be descended from species which had no lice. It is notable that the permanent ectoparasites of bats are minute or sedentary and that the periodic parasites breed elsewhere than on the host.

Many marsupials support Mallophaga but none is known to support Anoplura. All of the Australian members known to be infested average longer than 11 cm. from the tips of their noses to the roots of their tails. These included 13 Macropodidae (kangaroos and wallabies) out of 25 living species recorded by Marlow (1962), and 11 out of 58 species of other families.

All of the 23 species from which no lice are reported are less than 11.5 cm. long.

Three species of South American marsupials also are known to support Mallophaga. The known infested hosts are a moderate-sized opossum, (*Monodelphis domesticus*), a mouse opossum, (*Marmosa incana*), and a rat opossum (*Orolestes incae*). The smallest known infested species are about 12 cm. long. Of the 30 odd species of *Marmosa* listed by Cabrera and Yepes (1960), about a dozen are less than 12 cm. long and the remainder are longer.

None of the shrews of America nor moles of Eurasia is known to support lice but, surprisingly, two American moles (*Parascalops breweri* and *Scalopus aquaticus*) and several Eurasian shrews do support them. *Sorex araneus* and *Crocidura leucodon* of Europe; *C.*

horsfieldi of Ceylon; and *Suncus* (*Pachyura*) *luzoniensis, S. coerulans* and *Scutisorex conrecies* of Asia and its islands all support *R. reclinata. C. horsfieldi* also may support *Ancistroplax crocidurae.* Some of the smallest mammals of the world are uninfested: *Suncus eutruscus* (4.6 cm.), *Microsorax hoyi* (5.8-6.8 cm.) and *Sorex minutus* (4.3-6.4 cm.).

The average length of the European shrews not yet reported infested is 5.5-7.7 cm. and that of the known infested ones is 6.1-7 cm. cm. Head plus body of adult *Sorex araneus,* smallest of the infested species, measure from 5.8 to 8.7 cm. (van den Brink, 1947).

Johnson (1960:56) reported that "none of the *Crocidura religiosa* and *C. oliveri* collected in Egypt by NAMRU-3 were found infested by lice" and that "although light louse infestations might have been overlooked, Hoogstraal's data make it evident that Egyptian *Crocidura* rarely, if ever, carry sucking lice." Since all of the infested shrews bear some species of *Polyplax,* which probably were acquired from rodents or a mutual ancestor (Ferris, 1952:202), it appears that all shrews should have had opportunity to acquire *Polyplax,* or other lice, in both the Old and New Worlds. Also, since *Ancistroplax* and *Haematopinoedes* appear to have infested ancestral Insectivora (Hopkins, 1949:538), some should have been passed on to all descendants except as prevented by inhibiting factors. But only *C. horsfieldi* is credited with being the host of the former genus and two American moles with being hosts of the latter. Inhibiting factors, possibly size or some condition related to size supported by other adversities, prevented both inheritance and acquisition on the smaller shrews.

Four species of elephant shrews and a tree shrew, *Anathana ellioti,* all longer than 13 cm., support Anoplura. (Tree shrews are commonly classified as Primata though popularly known as shrews.)

If one adds the lengths of the uninfested American shrews, the uninfested shrew mole, *Neurotrichius gibbsii* (7.2-7.4 cm.) and star-nosed mole, *Condylura cristata* (13 cm.) to those of the uninfested Old World species, (5.5-7.7 cm.) the average size for all uninfested moles and shrews becomes 7.2-7.4 cm. The average of all infested shrews and moles is 8.0 cm. The terminal point of the line of decrement is slightly below that (7.0) suggested for house mice.

SUMMARY

1. Although lice of mammals are relatively faithful parasites of a given genus or species of host, loss and/or replacement does occur (Vanzolini and Guimaraes, 1955). Some lice transfer successfully to distantly related hosts (Hopkins, 1956 and Werneck, 1948).

2. A high percentage of the smaller mice and mouse-like species which have been examined are not known to support lice, or, when

they do, to support them only in localized areas and with low percentage infested.

3. Degression lines, calculated from the percentages infested suggest that at about 6.0 cm. average length of head and body, mammals usually are free of Anoplura even though larger members of their genus are infested. The presence of lice on mammals therefore is a relative matter, the percentage infested declining with the average size of the host species, subspecies or variety. The end point (6.0) of the degression line for *Microtus* examined by us was slightly below that (7.0) for house mice.

4. Large male *Microtus californicus* apparently support Anoplura more consistently than do large females, possibly because of more frequent contacts with males while fighting and with females when mating. Males also are slightly larger.

5. Mallophaga may not be able to maintain themselves on small host species as effectively as do Anoplura; their smallest known host species are about 11 cm. long. However many mouse-like species undoubtedly require examination adequate for lice.

6. Size of host among the larger species of mammals affects the number of species of lice which may infest individuals (Hopkins, 1957:88). Anoplura and Mallophaga are known to occur together on hosts as small as large Guineapigs (*Cavia* sp.) and more commonly on those as large as hyraxes (*Hyracoidea*) but not on mice. Two species of Anoplura are known to occur on single individuals of some species as small as large mice or small rats.

7. The percentage of hosts infested by the chiggers which we studied is measurably affected by both the size of the host and by the area of the host's home range.

8. Our method of measuring area of home ranges, using profile and end views and based on the composite method of averaging home-range area, yields products which frequently are somewhat smaller than the minimum home range method discussed by Cockrum (1962) but can be used to compare areas of circular, or other shapes of ranges, with those which are linear. The method yields products which are considerably smaller than does the circular concept for calculating home areas.

9. When measuring home areas by means of trapping, there is doubt about how far a given animal might have gone beyond the outer traps in which it was caught. Workers commonly add a boundary area of half the distance to the next traps. It is suggested that, since most ranges are elongate, half the distance to the next trap at either end of the animal's range be calculated as percentage of the length of range and that that *percentage as width* be added to the width of the observed range. The result usually will be a band wider

at the ends than at the sides of the observed range. Even so, the result will be of more use comparatively than as an absolute measurement.

10. The spacing of the traps also leaves doubt about the absolute range. We used 10-foot spacing which is much closer than other observers have used. Close spacing with respect to the real size and shape of an animal's home range tends to make the habitat more uniform with respect to distribution of food, and sometimes shelter, whereas wide spacing makes it ununiform.

11. As now interpreted, there are groups of mice and mouse-like or rat-like species which are thought to have evolved from a common ancestor but which harbor either Anoplura or Mallophaga (Jellison, 1942) indicating that acquisition of lice occurred after the host species became distinct. If so, and if the ancestral species were small, acquisition must have occurred after the hosts attained adequate size and subsequent geographic intermingling. Presumably size and additional inhibiting conditions must account for presence or absence of microorganisms transmitted by lice.

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NOTE.—We suggest several possible reasons in our 1962 paper re Linearity. Socio-sexual relations also may affect the shape of range or territory. Figure 5 for song sparrows in our 1962 paper is about 1 × 1.4 and Fig. 1B, p. 175 in Trans. 27th N. Amer. Wildl. & Natrl. Res. Conference (for red-talied hawks) is about 1 ×1.5. Both birds are pair bonded, uniterritorial, and notably aerial during their territorial seasons. Most birds of similar behavior also maintain compact ranges or territories, possbly for similar reasons.

Polygamous species have other problems: as stated by Mr. Stumpf, they must meet more of the opposite sex. Further, they are opposed by other members, usually of the same sex. Apparently they elongate their ranges or territories in the direction of least opposition. This is suggested by Elton's (1932) Fig. 1 (J. Animal Ecol.). For colonies of wood ants which act as individuals in a territorial sense. Also by Fig. 45 for hippopotamuses in Bourlière in the Natural History of Mammals, second edition. Both species are territorial.—Carl Mohr).

DISCUSSION

DISCUSSION LEADER ROBINSON: Again, Bill, a question from my vantage point. This has to do with home ranges.

You state that the home ranges of males are about 2.8 times as long as they are wide. Do you have any explanation why one dimension should be so much greater than the other?

MR. STUMPF: Again, as with the previous speaker, strong feelings but no data to point to precise reason.

We fell that there is a minimum basic size in terms of square yards on which a species can maintain a home range, maintain familiarity or defense, whichever is the controlling factor, and if this is arranged in a long, narrow piece of real estate, it will average out to sample more habitat which is favorable under all weather conditions and at different times of the year. As well, this allows the males to contact more females than in a compact circular area.

THE VIRUS OF EPIZOOTIC HEMORRHAGIC[1] DISEASE OF DEER

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The isolation of an agent causing fatal disease in white-tailed deer was first described by Shope, MacNamara, and Mangold in 1960. Subsequently Mettler, MacNamara and Shope (1962) suggested that the virus may be a member of the *Arbovirus* group because it was slightly reduced in infectivity by treatment with sodium desoxycholate and produced fatal encephalitis in suckling mice. The exact classification of the virus is of extreme importance in the edpidemiology and control of the naturally occurring disease. If the virus is an *Arbovirus,* that is, if it is normally transmitted by the bite of an arthropod, then a vector must be sought and eliminated in order to control the disease; if the virus belongs to another virus group then other control methods must be sought. The purpose of this paper is to describe the properties of this virus, to compare them to the properties of established virus groups, and finally to relate the classification of the virus to its possible epizootiology.

PROCEDURE

Virus source, Isolation and Properties.

In the late summer of 1962 there was a heavy die-off in white-tailed deer in the southeastern part of the province of Alberta. Characteristics of this die-off were rapid death, early decomposition of carcasses, and hemorrhagic changes in many body organs. Altogether, 440 white-tailed deer, 18 mule deer, and 13 antelope were found dead. Spleen material from one mule deer was injected into mice, guinea pigs, rabbits, and 7-day old embryonated hens' eggs. All animals and embryos appeared normal after injection but white-tailed deer injected with the material died with typical signs of epizootic hemorrhagic disease.

We received this frozen spleen material from Dr. E. N. Vance, Department of Agriculture, Province of Alberta, and isolated a virus from the spleen of a white-tailed deer which died seven days after inoculation with the material from Alberta. The virus was isolated in suckling mice and HeLa tissue culture cells by following the methods of Mettler and Shope (1962). Following the isolation the

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FIG. 1. Properties of the *Arbovirus* group, the *Picornavirus* group, and the virus of Epizootic Hemorrhagic Disease of Deer.

Property	*Arbovirus**	*Picornavirus*	*E.H.D.D.*
Nucleic acid type	RNA	RNA	RNA
Chloroform treatment	sensitive	not sensitive	not sensitive
Acid treatment	sensitive	sensitive/not sensitive	sensitive
50°C for 1 hour	sensitive	sensitive	sensitive
50°C + M $MgCl_2$ for 1 hour	more sensitive	stabilizes infectivity	stabilized partially
Size	25-100 mμ	25-30 mμ	25-30 mu
Symmetry	compound cubic or complex	simple cubic	simple cubic

*for well studied members of group so far.

nucleic acid type, the chloroform and acid lability, and the heat stability of the virus were determined by employing methods used in our laboratories (Ditchfield and Doane, 1964), using HeLa cells as the indicator system of virus infectivity before and after treatment. The size and symmetry of the virus were determined by purification of the virus by high speed centrifugation followed by electron microscopy.

RESULTS

Figure 1 gives the properties of the virus, plus the properties of the *Arbovirus* and *Picornavirus* groups. The symmetry and size of the virus are shown in Figure 2.

The virus of epizootic hemorrhagic disease is a ribonucleic acid containing virus, it is chloroform resistant, acid labile, and stabilized by M $MgCl_2$ at 50°C for one hour. The size of the virus is about 25-30 mμ, and it has simple cubic symmetry. The Canadian virus is serologically identical with the New Jersey strain of virus.

DISCUSSION

The reported properties of this virus are its ability to grow in HeLa cells and produce fatal encephalitis in suckling mice (Mettler and Shope, 1962). There are two serotypes of the virus, the New Jersey and South Dakota strains. Shope's work has been with the New Jersey strain while Pirtle and Layton (1961) have isolated and partially characterized the South Dakota strain using tissue cultures of white-tailed deer spleen. These workers found the virus to be relatively heat stable and to have a particle size of about 25 mμ. There is a serological relationship between the New Jersey and South Dakota Strains. They have a common complement fixing antigen and probably there is a degree of heterotypic virus neutralization; the latter point is a moot one since the two viruses have not yet been compared in a reciprocal fashion.

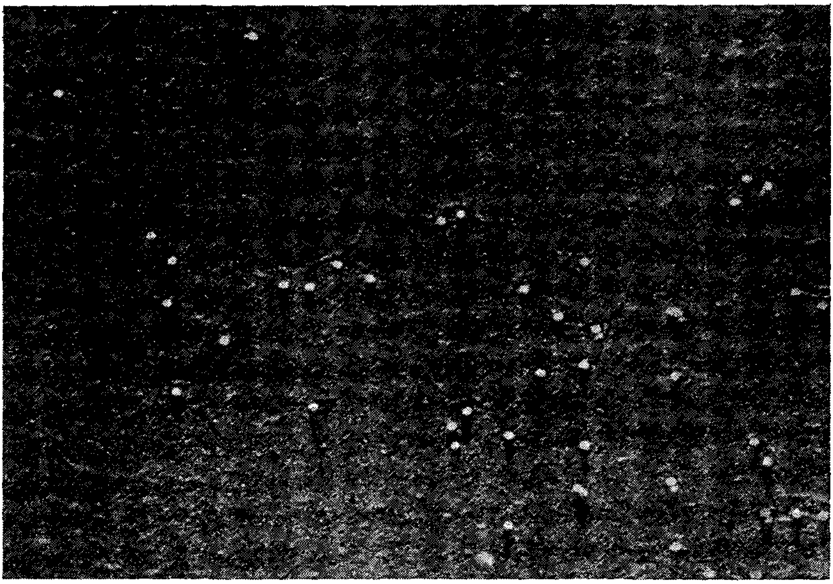

FIG. 2. A purified virus suspension of EHD viirus as seen in the electron microscope.

a *simple* cubic
virus with a
particle size
of 25-30 mu

The Alberta isolate is serologically identical to the New Jersey virus, and possesses all of the properties ascribed to the *Picornavirus* group, particularly of the encephalomyocarditis viruses. Thus we may expect that the epidemiology of the disease should proceed along the following lines:

We may postulate that the reservoirs of EHD in nature are either deer with asymptomatic infections or small rodents. In either case deer probably become infected by the oral route; most animals respond with an asymptomatic illness, but the occasional animal, because of either a marked susceptibility or a massive dose of virus, succumbs to the infection. Whether or not animals become clinically ill, a viremia is always present on the third to seventh day after infection. Biting insects may, during this time, feed on infected deer and mechanically transmit the virus to other deer. Generally this abnormal route of infection leads to death. Deer may also spread the disease through respiratory secretions.

In partial proof of this hypothesis we offer the following: In our hands deer injected either subcutaneously, intravenously, or intramuscularly, invariably die from the infection, generally in about seven days. These deer show the classical signs of EHD. Deer given the virus orally may show a fever on the fifth to seventh post-inoculation day, but other than this are not clinically ill. The infection is primarily enteric and virus is shed in the feces. Deer so infected are then resistant to challenge with the virus given by injection. They respond with a boost in antibody titer but there is no clinical disease.

Such reactions to a virus have many analogies in human virology. Infection with poliovirus, for example, results in less than 5% of exposed persons developing clinical disease. The other 95% may have a slight headache, a stiff neck, or a "summer cold," but most of them show no clinical signs of disease. Other examples in human enterovirus infections are numerous. In fact, all things being equal, it is safe to say that most virus infections are asymptomatic unless the host's defense mechanisms are deficient, or an abnormal route is used for the entry of the virus, or a massive dose of a highly virulent strain of virus is introduced. It would not profit these highly obligate, intracellular parasites, in the least, if they killed the host they depended on for their very existence. We submit that EHD virus in deer has this pattern of many asymptomatic infections with the clinical cases being exceptions and not the rule, and that the commonest portal of entry of the virus is through the mouth. The occasional extensive epizootics may arise when the virus is introduced into a population not recently exposed, where it may be transmitted by an abnormal route, *e.g.* by biting arthropods.

DISCUSSION

DR. JOHN R. ANDERSON (University of California, Berkeley, California): Would you expect transmission of this virus by the biting arthropods?

DR. DITCHFIELD: Yes, we would. It has been shown for other group members of the encephalomyocarditis group of viruses. I would think it quite possible of this virus, too. This is, exactly as you pointed out, a mechanical method of transmission.

DR. ANDERSON: If you get this high titer in the feces, then, I should think you would widen the scope of arthropods suspected, because there are a large number of dung flies associated with deer which feed on feces, and they feed around the eyes and other organs.

DR. DITCHFIELD: Yes; this is quite true. I don't think the viremia is high enough to actually infect an arthropod host. Certainly this method of feeding on fecal material and then feeding on deer is very likely among the epizootics.

DR. ANDERSON: What was the month the epizootic occurred?

DR. DITCHFIELD: This occurred during the month of August and the early part of September.

DR. DANIEL O. TRAINER (University of Wisconsin, Madison, Wisconsin): I have one comment and one question.

This is a very good example of the need for basic research if we are to arrive at any answers to some of these disease problems, and I think this paper pointed it out very nicely.

The question I have is along the same lines of John Anderson's. It seems that all of these outbreaks have occurred in either late August or September, and I was wondering if you care to comment a little further on how this fits into your hypothesis of how disease is maintained and spread in nature.

DR. DITCHFIELD: This we can't answer as yet. We know it has, again, many analogies in human virology, in that epidemics of aseptic meningitis, for example, occur in the late fall. Outbreaks of poliomyelitis occur in the late fall. Perhaps there is a relationship of a move of small rodents into and around watering areas where deer are—this is something that we have talked about. It is something we would like to check on, particularly in relation to the *Peromyscus* mouse, to see if the migration habits of these mice have any relation toward epizootics in deer. But I can't give you a positive answer on that at all.

DR. WALTER E. HOWARD (University of California, Davis, California): I am not sure you have any information from New Zealand, but I would like to ask you anyway. They have a unique situation with seven species of deer being introduced there, and in many parts of the country several of these exotic species are living together in the same habitat. These are wapitis, Hydropotes, whitetails and others.

The mortality factors of the deer are not at all well understood. They don't have the winter die-offs such as we see in this country because, they think, their browse species are all evergreen, and they don't have the winter die-offs. Do you have any information regarding the significance of virus diseases on that type of area? It looks like a very fertile place to study it, with all degrees of population density occurring from initial introduction to massive build-ups.

DR. DITCHFIELD: The only information I have on New Zealand is that we have two post-graduate students at Guelph who are from New Zealand.

There is little work being done on virus infection or infections among wildlife in New Zealand with the exception of hedgehogs. They study these intensively for fungus infections.

They have had die-offs, according to my informants, among deer. Some of these have shown pathological changes which are typical of EHD. I am not sure when they occur there and neither are they, but I agree with you, certainly, that New Zealand, being a fairly tight little island and being some 1200 miles away from the nearest land mass, would be a very interesting area to study for this particular population dynamics and for the role of disease in the population dynamics.

DR. PAUL I. SPRINGER (South Dakota Cooperative Wildlife Unit, Brookings, South Dakota): If the vector is a biting arthropod, do you have any idea what kind it might be?

DR. DITCHFIELD: I would think it would probably be *Crysops* or *Tabanis*. Crysops are incriminated, as you know, in tularemia in Utah. It is quite possible that since they are voracious feeders they could transmit virus mechanically. I believe that they feed more than once during one day on a number of animals.

This, I think, proves that you can not solve a problem by yourself; that you have to get many people from many different disciplines, all directing their particular talents toward the solution of a problem.

DR. SPRINGER: I am not sure about the analogy of *Crysops* in your area, but from my experiences most of them are of early summer appearance and would largely be gone by August or September.

DR. DITCHFIELD: Yes. So this, of course, leaves us with *Tabanis* or a similar type of fly.

Shope was unable to reproduce this disease by keeping deer together and exposing them to *Stomoxys flies.* He kept them in the same pen, infected and controls, and the controls didn't die, so he postulated that it wasn't an oral method of spread; that it had to be through a vector. But he had lots of *Stomoxys* around his deer and nothing happened.

We would like to think that his controls were already immune because of taking virus in orally.

DR. ARCHIBALD B. COWAN (University of Michigan, Ann Arbor, Michigan): I would like to ask about the incidence of the antelope, the pronghorn. If I am not mistaken, this is the first report of viral hemorrhagic disease occurring in anything other than deer.

Were these animals that were found this way in the same area as the epizootic with the deer? And would you care to comment on the appearance of a new animal in this chain that has been rather confused previously by not having another host animal to work with?

DR. DITCHFIELD: There were about thirteen pronghorns involved in this epizootic. They were in the area of the die-offs in white-tailed and mule deer. They had pathological changes typical of the infection. Spleen material from these antelope killed white-tailed deer. So presumably the pronghorns did die from hemorrhagic disease.

It is quite possible that, dealing with viruses from different localities, some of them may have a broader host spectrum than others. Some of them may be more virulent than others. I am not at all conversant with the wildlife population, whether or not antelope normally associate with white-tailed or mule deer. The only thing I know is that these antelope did die. They died from the Alberta strain, and the Alberta strain is identical with New Jersey.

CHAIRMAN FAY: Thank you, Dr. Ditchfield.

I think you have treated the subject quite adequately. I do appreciate the concepts which were brought out, the concept of characterizing studies of virus, identifying it to see how it fits in with other groups of viruses in which we do know something about epidemiology, and working from there to plot the chain of transmission, whatever is involved.

I think that saves a lot of aimless casting about in working out the epidemiology of a lot of these diseases.

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INFECTIONS DUE TO LISTERIA MONOCYTOGENES IN WILDLIFE[1]

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Listeriosis, or listeric infection, is one of the most recently recognized and least understood of all the bacterial infections of man, his domesticated animals, and the wildlife which share his cities, farms and recreation areas. The passing of 38 years since Murray *et al.* (1926) first described the bacterium known today as *Listeria monocytogenes* has added much to our knowledge of the bacterium. Today it is well known that *L. monocytogenes* is a significant cause of encephalitis in domestic ruminants; of septicemia in monogastric animals and birds; of meningitis in man, particularly during the perinatal period and in the years beyond 40; of abortion in many mammalian species; and a number of other disorders of lesser significance. Yet many misconceptions have been perpetuated: that infections with *L. monocytogenes* are rare; that all listeric infections are highly acute; that the central nervous system is always involved; that the bacterium is easy to cultivate from infected material. And much remains undetermined: the factors which dictate the type of infection in the various species; the natural reservoir of the bacterium; and the carriers who perpetuate and transmit the disease.

At present no intelligent estimate can be made of the incidence of any form of listeric infection, but it is not as rare as once suspected; merely rarely recognized. The disease has been reported from all inhabited continents and ranges from the Arctic to Australia, South Africa and Argentina. In addition to man the bacterium attacks or may be harbored by at least 42 different mammals and 22 fowl, including domesticated animals, house pets, zoo, laboratory, fur bearing, and feral animals. It has also been isolated from pond reared rainbow trout, crustaceans, ticks, lice, a house-fly, sewage, lake mud, stream water, a rodent's nest, oats, hay, silage, chaff, sand and dust. This broad distribution presents a peculiar paradox: at one and the same time *L. monocytogenes* apparently is distributed widely in nature, yet the sporadic occurrence of the disease suggests that its distribution is actually restricted; or that the bacterium is pathogenic and recognizable only under limited, specific conditions; or that it is overlooked; or that its presence cannot be detected by ex-

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isting culture methods. Much remains to be accomplished before there is a full understanding of this intriguing and elusive bacterium. And one enticing area for further study which has barely been explored is the possible role of wildlife in the perpetuation and transmission of the disease—a possibility often suggested but seldom investigated.

Little is known regarding the occurrence of *L. monocytogenes* in feral species and few attempts have been made to determine it. The bacterium has been isolated from dead, sick or healthy trapped ground game incidental to surveys on the incidence of *Pasteurella tularensis* or from rabies suspects. Listeric septicemia has followed incarceration of lemmings (Plummer and Byrne, 1950; Barrales, 1953; Magus, 1955), voles (Levy, 1948), and merions (Balozet, 1956) for laboratory use, and administration of large doses of cortisone to a lemming. *L. monocytogenes* has also been isolated from a "pet" squirrel, a variety of captured or dead free-living birds, and less frequently from wild and captive canines, deer and a feral moose (Table 1). And there might be justification, but not space, for including several zoo animals which developed the disease shortly after being placed in captivity. These reports imply a rather wide distribution of *L. monocytogenes* among feral hosts. But what is needed is more than mere implication. The true significance of feral species in the total listeric infection complex can be properly evaluated only when those engaged in wildlife conservation and in the study of diseases of wildlife are aware of the possible presence of the bacterium and the difficulties that may be encountered in attempting to demonstrate its presence. This presentation is an attempt to stimulate such an awareness, and to bring together what is presently known regarding the distribution of *L. monocytogenes* among wildlife.

Only one year after Murray *et al.* (1926) first described *L. monocytogenes* after isolating it from laboratory rabbits and guinea pigs, Pirie (1927) in South Africa isolated it from the livers of several feral gerbils during an epidemic of septicemia in the Tiger River district of the Orange Free State. As the bacterium appeared to be nonpathogenic for several species of mice and rats, baits infected with *L. monocytogenes* were placed in the area in an effort to control the gerbil population. In view of present knowledge it is fortunate this failed and was quickly abandoned.

The next isolation from a feral source, a wood grouse in Sweden, was not recorded until World War II (Lilleengen, 1942). Since then a steady trickle of similar reports, the first in this country in 1947 (Gifford and Jungherr, 1947), has grown to more than 50 from all parts of the world.

On this continent interest in the occurrence of *L. monocytogenes* in wildlife was born at Churchill, Manitoba. These studies, and others from northeastern Canada, vividly reveal the tantalizing frustrations that constantly harass those who attempt to unravel the complex epidemiology of listeric infection. The enticing missing link, often apparently within grasp, always eludes the investigator's quest.

As early as 1949 lemmings captured in the Churchill area died from listeric infection when incarcerated for laboratory use there or in other provinces (Plummer and Byrne, 1950), strongly suggesting that these lemmings might be carriers of *L. monocytogenes.* This suspicion was further strengthened when several laboratory workers in Churchill developed vague symptoms simulating low grade listeric septicemia. It also stimulated speculation that the bacterium might be involved in the so-called "lemming crashes." Despite considerable effort, Nordland (1959) failed to establish any connection between the infected lemmings and the disorder among the laboratory personnel, or that the bacterium could be incriminated in lemming crashes. However, by injecting 10 lemmings from Churchill with large doses of cortisone, a substance known to enhance susceptibility to the bacterium, Nordland (1960) demonstrated one carrier among this group. Further evidence of carriers is found in the isolation of *L. monocytogenes* from the brain of an infected arctic fox (Nordland, 1959), and from the intestinal tract of an apparently healthy snowy owl shot in northern Ontario (Reed, 1955), species known to prey on lemmings. These observations, and those following, suggest that *L. monocytogenes* is carried through the full circle of the arctic energy cycle, but without being a significant ecological factor.

An intriguing story from Labrador involved man and sled dogs known to feed on lemmings and hares. *L. monocytogenes* was isolated from the brain of two dogs during a period of heavy losses due to a distemper-like disease. That year, 1955, practically no rabbits were seen on the Labrador coast and those caught were thin with patchy loss of hair. At the same time an Eskimo developed acute meningitis, was treated with antibiotics, and flown to a hospital where smears of spinal fluid showed numerous gram positive rods resembling *L. monocytogenes.* Unfortunately, all cultures remained sterile, presumably due to early antibiotic treatment. Subsequently *L. monocytogenes* was isolated from several hares in this area, but its role in the decline of the hare population could not be established. (McKercher and Archibald, 1959).

Another story from Labrador concerns an Eskimo who died from what almost certainly was listeric infection after skinning a caribou—a species reported to eat lemmings occasionally, perhaps by accident.

Apparently no effort has been made to isolate the bacterium from caribou, but it has been isolated from a moose in Nova Scotia (Archibald, 1960). However, the true epidemiological significance of all this remains as silent and unknown as the land in which it occurred.

Somewhat less mystery shrouds the 10 confirmed cases of listeric infection in man recorded in Nova Scotia and Newfoundland (Reed *et al.,* 1955; Girard and Gavin, 1957; Josephson *et al.,* 1958). As usual, no epidemiological link could be established. Moments of conjecture on the part that wildlife may have played is a permissible pastime. But of infinitely greater value would be positive steps to determine whether these are truly important links, or merely imaginary, or an easy placing of blame on those who have no means of defense.

Few attempts have been made to assess the distribution of *L. monocytogenes* among ground game or free-living birds. The first was incidental to a survey on the distribution of *P. tularensis* in the Soviet Union. Of 27,122 specimens examined between 1946 and 1948, *L. monocytogenes* was isolated from eight captured or dead field voles, a water rat, a water shrew, and a common shrew (Olsufev and Emelyanova, 1951).

A second study revealed *L. monocytogenes* in two of 58 voles also infected with *P. tularensis.* The authors implied that *L. monocytogenes* was also isolated from a number of other voles found in piles of straw and haystacks in the same area and concluded that the disease in voles is usually chronic (Olsufev and Emelyanova, 1954). Kratokhvil (1953) suggested that tularemia checking stations were in an excellent position to determine the distribution of *L. monocytogenes* among ground game. It is not known how widely this suggestion has been followed, but the bacterium has been isolated from voles and a jack rabbit in Washington State as a result of such a study (Bacon and Miller, 1958).

From 1953 through 1961, examination of 156,400 rodents captured in and around Moscow showed *L. monocytogenes* in 20 grey rats, 21 house mice, 39 "common voles," and 3 "red voles"; or according to the author, one isolation per 1,250 specimens. Two cultures were isolated from "birds" (Ogneva, 1962).

An investigation of 939 free-living mammals and 564 birds in Czechoslovakia resulted in three isolations of *L. monocytogenes*: one from a long tailed mouse, yellow wood mouse and common rat (Seeman, 1957). However, similar investigations involving several hundred animals failed to reveal the bacterium even in areas where the disease was endemic in domestic animals or man (Sichert *et al.,* 1960; Jasinska, 1961; Kita and Tropilo, 1961; Larsen, 1963), or where the bacterium had previously been isolated from feral sources

(Weidenmüller, 1958). Only Weidenmüller (1958) used the refrigeration method (Gray, 1962) for isolation attempts. Had this been employed more generally, the number of isolations might have been increased.

Most isolations of *L. monocytogenes* from feral hosts were made from sporadic cases of the disease, or from apparently healthy animals, or those which died of other causes. The known isolations are shown in Table 1.

Table 1 suggests that listeric infections are rare among feral hosts in this country. A more likely explanation is that little effort has been made to find it.

The circumstances under which most isolations were made suggest that almost all animals may be potential carriers, but give little clue to how long they may remain so, or how or where they contact the bacterium, or what part they actually play in perpetuation and spread of the disease.

Few reports can be linked with the disease in other species. Apparent associations have been recorded between voles and sheep (Olsufev and Emelyanova, 1951); skunks and abortion in cattle (Osebold *et al.*, 1957); deer and sheep (Thamm, 1957); partridges and sheep (McDiarmid, 1962); rats and sheep (Malakhov, 1962); and a pet squirrel and a boy (Chernousova and Putiato, 1957).

The clinical picture in naturally infected feral mammals is obscure, as most are found dead or captured in traps. When observed shortly before death or capture, symptoms were usually those associated with septicemia, not meningitis. The most characteristic gross lesion is the presence of varying numbers of well-defined whitish-gray foci on the liver and/or spleen, lungs and heart. The foci are essentially identical to those seen in tularemia or pseudotuberculosis.

Histologically, there are focal areas of necrosis infiltrated with neutrophiles, and little involvement of the adjacent tissue. The bacterium is usually located at the periphery of the lesion and may be either intra- or extracellular.

The uterine contents of many mammals are highly vulnerable to invasion by *L. monocytogenes,* and what quite likely was listeric abortion has been reported in hares (Vallee, 1952; Nilsson and Karlsson, 1959; Larsen, 1963). Listeric infection should be considered in any animal showing a necrotic metritis.

L. monocytogenes may also attack or be harbored by feral ruminants. It is striking, and of no presently obvious significance, that encephalitis is the predominant manifestation of the disease in domesticated ruminants, while septicemia is seen most frequently among feral ruminants. An interesting exception is the isolation of *L. mono-*

TABLE 1. ISOLATION OF *LISTERIA MONOCYTOGENES* FROM FERAL HOSTS

Species	Country	References
MONOGASTRIC MAMMALS		
Gerbile		
Tatera lobengulae	South Africa	Pirie, 1927
Meriones shawi	Algeria	Balozet, 1956
Meriones meridianus & *Rhombomys* spp.	USSR (Alma-Ata)	Martinevskii, 1961
Mouse		
Apodemus sylvaticus & *Cleithrionomys glareolus*	Czechoslovakia	Seeman, 1957
"House mouse"	USSR (Moscow)	Ogneva, 1962
	Denmark	Larsen, 1963, unpublished
Vole		
Microtus agrestis	England	Levy, 1948
M. arvalis	USSR	Olsufev and Emelyanova, 1951, 1954; Kratokhvil, 1953; Glagoleva and Emelyanova, 1955;
M. montanus	Washington	Ogneva, 1962
"Red vole"	USSR (Moscow)	Bacon and Miller, 1958
"Vole"	Sweden	Nilsson and Karlsson, 1959
Lemming		
Lemmus trimucronatus trimucronatus, *Dicrostonyx groenlandicus groenlandicus* & *D. g. richardsoni*	Manitoba Northwest Territory	Plummer and Byrne, 1950; Barrales, 1953; Magus, 1955; Nordland, 1960
Hare		
"Hare"	Sweden	Henricson, 1943; Wramby, 1944; Nilsson and Karlsson, 1959
	Finland	Stenberg, 1961
	Norway	Nordøy *et al.*, 1960
	Denmark	Larsen, 1963
	Germany	Weidenmuller, 1958; Weidlich, 1959
	France	Vallee, 1952; Lucas *et al.*, 1955
	Switzerland	Bouvier *et al.*, 1954
	Poland	Skrodzki and Sokolowska, 1953
	Newfoundland	McKercher and Archibald, 1959
Lepus californicus wallawalla	Washington	Bacon and Miller, 1958
Raccoon		
Procyon lotor	Connecticut	Gifford and Jungherr, 1947
Skunk		
Mephitis mephitis	North Dakota	Bolin *et al.*, 1955
	California	Osebold *et al.*, 1957
	Canada	Avery, 1960, unpublished
Rat		
"Wild rat"	Brazil	Macchiavello, 1942
Rattus norvegicus	Czechoslovakia	Seeman, 1957
	USSR (Moscow)	Malakhov, 1962; Ogneva, 1962; Ponomareva *et al.*, 1962
Arvicola terrestris	USSR	Olsufev and Emelyanova, 1951
"Water rat"	USSR (Siberia)	Kaplinskii *et al.*, 1962
Muskrat	Minnesota	Barnes, 1962, unpublished
Shrew		
Neomys fodiens & *Sorrex araneus*	USSR	Olsufev and Emelyanova, 1951
Sable		
Mustela zibellina	USSR	Eremeev and Stepanenko, 1962
Marmot	USSR	Timofeeva and Golovacheva, 1962
Fox		
Alopex lagopus	Manitoba	Nordland, 1959
"Fox"	Ontario	Avery and Byrne, 1959
	Georgia	Scholtens and Brim, 1964
RUMINANTS		
Deer	Germany	Thamm, 1957; Hörter and Hunsteger, 1960
	Sweden	Nilsson and Karlsson, 1959
	Wisconsin	Trainer, 1962, unpublished
Moose	Nova Scotia	Archibald, 1960
BIRDS		
Grouse		
Tetrao urogallus	Sweden	Lilleengen, 1942
Ptarmigan	Finland	Stenberg, 1961
Partridge		
Alectoris rufa & *A. graeca chukar*	France	Lucas *et al.*, 1962
"Partridge"	England	McDiarmid, 1962
	Denmark	Larsen, 1963
	Netherlands	Donker-Voet, 1963
Pheasant	France	Lucas *et al.*, 1962
Wild Duck	Sweden	Nyström and Karlsson, 1961
Crane	Finland	Stenberg, 1961
House sparrow	Denmark	Larsen, 1963, unpublished
Starling	Denmark	Larsen, 1963, unpublished
Whitethroat	England	Jennings, 1955
Magpie	USSR	Kaplinskii *et al.*, 1962
Snowy owl	Ontario	Reed, 1955, unpublished
CAPTIVE ANIMALS		
"Coyote"	Ontario	Karstad, 1961, unpublished
"Squirrel"	USSR	Chernousova and Putiato, 1957

cytogenes from the brain of a moose in Nova Scotia thought to be suffering from moose disease, which clinically mimics listeric encephalitis (Archibald, 1960). In fact, *L. monocytogenes* was once given serious consideration as a possible etiological factor. However, bacteriological studies using the refrigeration method (Gray, 1962) failed to reveal the bacterium in the brain of a considerable number of moose with the disease (Gray, 1955; Benson, 1958). Apparently the moose in Nova Scotia either died from primary listeric infection, or was a carrier while afflicted with moose disease.

Primary listeric infections are rare in fowl, but secondary or inapparent infections are fairly common (Gray, 1958). The disease is most frequently characterized by septicemia, and the most conspicuous lesions are massive areas of myocardial degeneration, or greyish-white necrotic foci on the epicardium and/or the liver.

Lucas *et al.* (1962), who have isolated *L. monocytogenes* from the largest number of free-living birds, found no pathognomonic symptoms or lesions. Instead they found a variety of primary conditions, and rarely necrotic foci. They concluded that most listeric infections in free-living birds are either secondary or latent, and that birds constitute the most important reservoir of infection. *L monocytogenes* should be given consideration whenever gram positive rods are isolated from free-living birds.

The now established relationship between silage feeding and listeric infection in ruminants is one of the most tantalizing bits of evidence that feral carriers of *L. monocytogenes* may be of economic importance. Since 1960 *L. monocytogenes* has been isolated from various types of silage in the United States and Europe (Gray, 1963). It is not yet known how the bacterium is introduced into silage. One possibility is ground game or birds which nest or burrow in it. If this is true, and *L. monocytogenes* has been isolated from a rodent's nest and "chaff" contaminated by rodent urine (Pomanskaya, 1957), it implies that the number of carriers, or number of organisms excreted must be fairly high as some silage contains large numbers of the bacterium. It is not known whether *L monocytogenes* can multiply in silage, but it can survive more than 20 months. It is imperative that studies be directed to either convict or acquit ground game and birds of their role in this complex, or of contaminating other animal feed.

The role of ectoparasites or other vectors in the listeric infection complex has received scant attention. *L. monocytogenes* has been isolated from *Oestrus ovis* larvae taken from the nose of infected sheep (Gill, 1957; Kato and Murakami, 1962), and from mice inoculated with suspensions of macerated ticks of several species: *Derma-*

centor pictus (Olsufev and Emelyanova, 1951), *Ixodes ricinus* (Kratokhvil, 1963), *Haemolaelaps glasgowi* (Ogneva, 1962), and *Ix. persulcatus* and lice from a "common vole" (Shylgina, 1963). It was also recovered from a house fly caught in a laboratory (Bojsen-Møller, 1962). This subject warrants further study, especially since a woman in Austria who died from listeric meningitis had a large insect bite on one arm (Schmidt, 1955), and a deer hunter in Virginia developed the disease after hunting in an area heavily infected with ticks (Welshimer and Winglewish, 1959).

Stamatin *et al.* (1957) in Rumania and Thibault *et al.* (1963) in France isolated *L. monocytogenes* from the viscera of pond reared rainbow trout thought to have been infected from contaminated meat. Symptoms and lesions were suggestive of septicemia. Mortality ranged from 30-70 per cent. The disease could be transmitted artificially to trout but not to carp. Whether *L. monocytogenes* can also attack free-living fish of this or other species is a moot question. However, listeric infection should be considered in the differential diagnosis of fish dying with septicemia.

Shlygina (1959) isolated *L. monocytogenes* from crustaceans gathered in the same stream from which Olsufev *et al.* (1959) isolated the bacterium. It is doubtful that the crustaceans were actually infected. However, this established that *L. monocytogenes* may be carried and spread by aquatic life.

L. monocytogenes has not been isolated from salt water fish.

Determination of the distribution of *L. monocytogenes* among feral hosts is hampered by the difficulty of obtaining good specimens for culture. The bacterium is often difficult to isolate, especially from contaminated specimens such as those from animals found dead in the field. It may be more than coincidence that at least 12 isolations from feral hosts were made by investigators who had previous experience with the bacterium in other species. This reemphasizes that awareness is still an important factor in recognizing the bacterium.

L. monocytogenes is a small, gram positive, non-spore-forming, extremely resistant, diphtheroid-like rod with a peculiar tumbling motility at room temperature, but non-motile at 37° C. It is aerobic to microaerophilic, and non-toxagenic. Colonies on blood agar incubated 18-24 hours at 37° C. are round, 0.2-0.8 millimeters in diameter, slightly raised with an entire margin, and usually show a narrow zone of *beta* hemolysis. Cultures are easily confused with hemolytic streptococci and often mistaken for and discarded as "contaminating diphtheroids."

Although *L. monocytogenes* grows well on most media *after* isolation, it may be difficult to isolate. This fact is often ignored with the consequence that some cultures are missed. The bacterium's peculiarities and elusiveness are elaborated elsewhere (Gray, 1962). The following is the most practical isolation method for use in a diagnostic laboratory.

Suspect tissue should be macerated in a mortar or blendor together with a few milliliters of sterile water or nutrient broth, and a portion plated on tryptose, trypticase, or blood agar; the remaining suspension placed at 4° C. Body fluids and swabs should be plated, then stored at 4° C. After 18-24 hours incubation at 37° C. colonies on clear media when examined with a scanning microscope, or a hand lens with the plate resting on a laboratory tripod, using obliquely transmitted illumination, are a characteristic and distinctive blue-green color.

If the initial culture fails to reveal *L. monocytogenes* after 72 hours' incubation, the refrigerated material should be replated at intervals of several days for at least three months. Usually only a few days or weeks of refrigeration are required for the bacterium to appear, but sometimes it may take several months. This method has serious disadvantages for the diagnostician and is cumbersome for the laboratory staff, but it enhances the probability of isolating *L. monocytogenes* by 20-90 per cent. A diagnosis of listeric infection cannot be eliminated merely by failure to isolate the bacterium on initial culture attempts.

Most isolations from ground game or ticks in the Soviet Union were made by intraperitoneal inoculation of mice. This may be a more effective isolation method than the use of non-living media. In this country and Canada several isolations have been made from mice inoculated intra-cerebrally with brain tissue from feral skunks, muskrats, and foxes thought to have rabies.

The most significant instance of this occurred in the spring of 1963 and involved five foxes thought to have rabies captured in scattered counties of Georgia (Scholten and Brim, 1964). Mice inoculated intracerebrally with these fox brains died three to five days after exposure and *L. monocytogenes* was isolated from all mice. Rabies laboratories should be aware of this possibility and all mice which die within the first six post-inoculation days should be cultured for *L. monocytogenes*. They should also be aware that both rabies and listeric infection may occur in the same animal. This has been reported in a cow (Gray *et al.*, 1951) and a feral fox (Avery and Byrne, 1959).

Usually the liver and/or spleen are cultured for detection of carriers of *L. monocytogenes*. Ponomareva *et al.*, (1962) claim that swabbing the pharynx is the most effective method with the common rat. Perhaps the most potentially rewarding source, feces, has been completely overlooked. Artificially infected animals excrete large numbers of the bacterium in the feces. Unpublished studies applying modifications of the refrigeration method to feces from chinchillas, mink, dogs, cows, chickens, sparrows and starlings (Larsen); cows (Dijkstra); and man (Bojsen-Møller) suggest this as the most favorable source for detection of clinically healthy carriers. By implication this makes carriers extremely important in the spread of the disease.

The material presented suggests that many different feral hosts may harbor *L. monocytogenes*, but it does not support the notion that *listeric infection* is widespread among them. Neither does it give a clear answer to how widely the bacterium may be distributed among wildlife, or the importance of their role in the perpetuation and spread of the disease. Although the disease appears to be self limiting among feral animals, if infected carcasses or carriers are eaten by carnivorous animals or birds these may constitute a further spread for the bacterium. Much new effort employing refined isolation methods and new sources for culture, especially body excretions is imperative before conclusive answers can be given to the many questions still surrounding this baffling bacterial infection.

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DISCUSSION

DISCUSSION LEADER ROBINSON: You mentioned that foxes suspected of having rabies have been diagnosed as having Listeriosis. Is there any way that we wildlifers can tell the difference between the two diseases in the field?

DR. GRAY: I am afraid that there is just no way that you could distinguish between the two diseases, because the bacteria may sometimes attack the brain in animals such as a fox or any canine animal. But perhaps what is a more useful thing is that the animal actually has a septicemia, but then the bacterium, since it is in the blood, does get into the meninges, the covering over the brain, and establishes inflammation there, which would lead to symptoms that would simulate those of rabies, and symptoms that could be confused with rabies have also been seen in captive foxes or in fur foxes, although there, because there was no reason to suspect rabies, they usually said it was a distemper-like disease, and then they isolated Listeria from the brain.

So I don't think you really can go on the basis of symptoms. They would be too easy to confuse.

DR. L. H. KARSTAD (Ontario Veterinary College, Guelph, Ontario): I would like to compliment Dr. Gray on the paper that he has presented. Certainly those of you who have been fortunate enough to get what he has mimeographed will see that he has included a tremendous wealth of information. This certainly will be a very valuable reference work for us in the future, and I would like to remind everyone that this infection has been Dr. Gray's consuming interest for many years, and he has been of help to me even though my laboratory is considerably removed from his.

I am certain that if any of you have interest in Listeria and require help in typing, identification and so on, Dr. Gray will be only too happy to come to your assistance.

Can you confirm that, Dr. Gray?

DR. GRAY: I will be glad to confirm that, Dr. Karstad—I mean the last part I will confirm. I don't know whether I am in a position to confirm the kind things you said about the paper.

One thing I did try to do in the formal presentation is bring together everything that I could find on the viral infections in wildlife, and this is something that has never been done before. I know there are some omissions which were found after the paper was completed, but if anyone does encounter bacterium that they think might be Listeria, they can send it to the Department of Veterinary Pathology at the University of Illinois and we will be glad to look at it and to type it.

CHAIRMAN FAY: Thank you, Dr. Gray.

In the way of explanation, I might mention that Dr. Gray expects to change positions. He will be at the University of Illinois.

THE ACCUMULATION OF FALLOUT CESIUM-137 IN NORTHERN ALASKAN NATIVES[1]

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We are currently investigating amounts of radioactive fallout, particularly cesium-137, in northern Alaskan Eskimos and Indians which exceed by nearly two orders of magnitude those in other peoples of the United States. We are relating results to food habits of various ethnic groups of native people and attempting to determine how and why various Alaskan animals, including man, concentrate different amounts of radionuclides.

The present study extends research begun in 1959 to describe the distribution of fallout radionuclides in Arctic ecosystems (Watson, Hanson, and Davis, 1963). Important differences were found in radionuclide concentrations in plants and animals from various environments, and the atmosphere-to-lichen-to-caribou-to-man food web was early recognized as the major source of Cs^{137} in native residents of northern Alaska.

The development of a semi-portable whole-body counter (Palmer, 1961) provided a capability to measure radioactivity in peoples of remote areas and to evaluate the influences of diet and environment upon accumulation of fallout radionuclides in various trophic levels of Arctic food webs.

STUDY DESIGN

Eskimos of northern Alaska represent two major ecological groupings, the inland and the coastal peoples (Spencer, 1959). The food gathering cultures of these people differ considerably; inland people rely upon caribou (*Rangifer arcticus*) for most of their food, while coastal Eskimos utilize sea mammals extensively and caribou and/or reindeer (*R. tarandus*) moderately. Intergradations of both cultures occur among Eskimos inhabiting villages along the Noatak and Kobuk River systems in northwestern Alaska. Availability is the main regulator of food consumption and introduces important seasonal differences in utilization of food sources.

Anaktuvuk Pass, Barrow, Kotzebue, and Point Hope were studied during the summer of 1962 on the basis of their location (Figure 1), composition of the native population, and sources of native foods. Anaktuvuk Pass residents represent an outstanding remnant of formerly nomadic "inland people" whose livelihood depends heavily

[1]Work performed under Contract No. AT(45-1)-1350 between the Atomic Energy Commission and the General Electric Company.

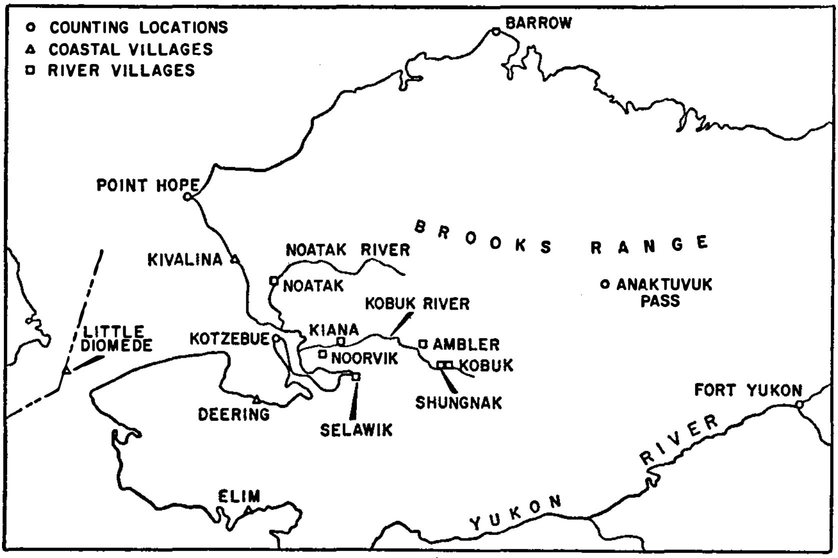

Figure 1. Map of northwestern Alaska showing native Villages and whole-body counting locations.

upon caribou. Barrow and Point Hope were selected as two villages representing the coastal people. Kotzebue serves as a major center for trading, medical care, and summer residence for Eskimos from river villages, Little Diomede Island and nearby coastal villages. Moving the counter from one location to another afforded an opportunity to examine people representing a variety of ethnic groups and food habits.

During 1963 these same locations were revisited and as many persons as possible were re-examined. In addition, native residents of the Athabascan Indian village of Fort Yukon were included in the study to provide comparison of Cs^{137} body burdens in natives who utilize moose (*Alces alces*) as a major food source during fall and winter months, with those who rely upon caribou and reindeer during those seasons.

Dietary information was obtained from the people at time of counting during both years, and samples of indicated important native and imported foods were obtained for radiochemical analysis to evaluate the sources of radionuclides.

The Anaktuvuk Pass residents were selected for study of seasonal changes in Cs^{137} body burdens. The first measurements taken other than in the summer months were made during January 1964.

RESULTS

Cesium-137 was the most important, and usually the only, fallout radionuclide detected in gamma spectra of 708 Eskimos examined during 1962, and 588 Eskimos and Indians during 1963. Zinc-65 was detected in two persons who consumed significant amounts of canned oysters. Zirconium-95-niobium-95 was usually present in spectra of subjects who did not change into the uncontaminated clothing provided and was easily detected in food items exposed to the atmosphere, especially during the 1962 study period. Both Zn^{65} and Zr^{95}-Nb^{95} were of little consequence to the general pattern of radionuclide transfer into man.

Cesium-134 was detected in spectra of persons containing the higher body burdens of Cs^{137} (Palmer and Perkins, 1963).

Cesium-137 Body Burdens in Eskimos and Indians.

Average Cs^{137} body burdens of adult natives of various ethnic groups retained the same general ranking during both years of study (Table 1). Body burdens were directly related to the amount

TABLE 1. COMPARISON OF ADULT NATIVE CESIUM-137 BODY BURDENS DURING 1962 AND 1963 AT VARIOUS ALASKAN ESKIMO AND INDIAN VILLAGES.

Location	Cs^{137} body burden (nanocuries)					
	1962			*1963*		
	N[1]	x[2]	S.E.[3]	N	x	S.E.
Anaktuvuk Pass	39	450	27	44	640	97
Kotzebue	112	150	7.6	102	120	1.9
River villages	35	150	14	16	150	60
Barrow	248	55	2.0	119	65	3.1
Point Hope	80	19	1.2	78	40	2.0
Coastal villages	8	100	16		—	
Little Diomede	15	29	3.4		—	
Fort Yukon		—		56	37	4.5

[1] Number of persons
[2] Mean
[3] One standard error of mean

and constancy of caribou and reindeer consumption; highest amounts occurred in Anaktuvuk Pass residents and lowest amounts were found in Fort Yukon residents.

Persons between 21 and 50 years of age usually contained greater amounts of Cs^{137} than did children or older people. Among family members, husbands contained twice as much Cs^{137} as their wives and about three times that of their children.

Average and maximum Cs^{137} body burdens in Anaktuvuk Pass residents during three periods of observations were as follows:

Date	Cs^{137} body burden (nanocuries)[2] Average	Maximum
July 1962	450	790
June 1963	640	1,200
January 1964	450	760

[2]Radiological units of measurement are expressed as fractions of a Curie. Common terms are microcurie (10^{-6} Curie), nanocurie (10^{-9} Curie), and picocurie (10^{-12} Curie). Cesium-137 body burdens are usually expressed in nanocuries.

Food Habits of Eskimos and Indians.

Dietary information obtained from the natives counted showed a wide range of food consumption rates and important seasonal changes in diet (Table 2). Native animals contributed about 40 to 70 per cent of the total diet by weight. Caribou were relatively most important at Anaktuvuk Pass and least important at Fort Yukon. The Anaktuvuk Pass Eskimos provide themselves with a fairly constant meat supply by killing substantial numbers of caribou during spring and fall periods each year and storing the carcasses in frozen underground caches during summer months. Similar practices are followed

TABLE 2. PER CENT OF NATIVE ANIMALS IN TOTAL DIET OF ALASKAN ESKIMOS AND INDIANS DURING VARIOUS SEASONS AS ESTIMATED THROUGH INTERVIEWS, SUMMER 1963.

Location and season	Caribou-reindeer	Marine mammals	Fish	Fowl	Moose	Bear	Other mammals	Total
Anaktuvuk Pass (42)[1]								
Spring	59			1	1	tr		61
Summer	54		1	1	tr	tr	tr	56
Fall	57		1	1	tr	tr	2	61
Winter	55		1	4	1		1	62
River villages (16)								
Spring	28	11	20	4	2	tr		65
Summer	25	6	23	1	1	tr		56
Fall	31	tr	28	5	3	tr		67
Winter	34	1	25	4	3	tr		67
Barrow (115)								
Spring	17	13	8	12		tr		50
Summer	22	18	9	1				50
Fall	23	17	8	1				49
Winter	26	8	15	1		tr		50
Kotzebue (76)								
Spring	18	15	6	2	tr	tr		41
Summer	17	4	15	tr	4	tr		40
Fall	21	5	14	2	5	tr		47
Winter	25	4	11	1	1	tr		42
Point Hope (81)								
Spring	7	27	tr	4	tr			38
Summer	16	5	16	1	tr			38
Fall	21	5	16	2				44
Winter	17	11	8		tr	10		46
Fort Yukon (52)								
Spring	3			8	10	tr	22	43
Summer	1		35	1	3	tr	tr	40
Fall	11		3	6	18	tr	1	39
Winter	9		6	1	20		6	42

[1] Number of people interviewed

by coastal Eskimos. The Indians at Fort Yukon do not practice such underground storage of meat, however, and thus utilize caribou and moose only sparingly during spring and summer months. Reindeer were eaten most by Barrow and Kotzebue residents as a supplement to caribou. Fish, the second most important meat source of the people examined, were utilized most heavily by residents of villages on the Noatak, Kobuk, and Yukon Rivers and least by Anaktuvuk Pass natives. Moose were most important in the Fort Yukon diets, in which they contributed about twice as great a percentage as caribou and were used mostly during the same seasons as were caribou. Bear (*Ursus arctos*, *U. americanus* and *Thalarctos maritimus*) meat was eaten sparingly at all villages; Point Hope Eskimos occasionally ate substantial quantities of it, contributed by "white hunters" during the polar bear season.

Walrus (*Odobenus rosmarus*), ringed seal (*Phoca* [*Pusa*] *hispida*) and the bearded seal or ugruk (*Erignathus barbatus*) were the most important marine mammals taken by all Eskimos, although black or bowhead whales (*Balaena mysticetus*) provided considerable amounts of food during spring months at coastal villages. Belugas or white whales (*Delphinapterus leucas*) were taken during spring and early summer months by coastal residents and also by river village Eskimos at temporary camps on Kotzebue Sound. An important "by-product" from marine mammals is seal or whale oil which most Eskimos consume with meat courses, particularly with dried meat.

Land mammals such as the hare (*Lepus othus*), ground squirrel (*Citellus parryi* and *C. osgoodi*), beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), porcupine (*Erethizon dorsatum*), spotted seal (*Phoca vitulina*), and Dall sheep (*Ovis dalli*) were utilized during seasons when they were in prime condition and available; the smaller members of this group were particularly important to Fort Yukon Indians and river village Eskimos. Anaktuvuk Pass residents were the principal consumers of Dall sheep.

Several kinds of fish and birds from a variety of habitats were utilized depending upon the village and season under consideration. At Point Hope, for example, the people obtained Arctic char (*Salvelinus alpinus*) from the Arctic Ocean during August, grayling (*Thymallus arcticus*) from the Kukpuk River during September and October, and tomcods (*Boreogadus saida*) from the ocean and lagoons during winter months. Whitefish (*Coregonus* spp.) were the most important fish item in Barrow diets, with grayling second; these fish were obtained from various lakes and streams in the area. Fort Yukon residents ate salmon (*Oncorhynchus* spp.) in summer and whitefish in winter. Utilization of bird species depended largely upon their availability. Coastal Eskimos utilized several species of eiders, murres, and auklets, depending upon location. River village Eskimos and Indians obtained river and diving ducks, and ptarmigan. Anaktuvuk Pass residents utilized willow and rock ptarmigan (*Lagopus lagopus* and *L. mutus*), especially during winter months.

The consumption of imported foods was greatest in the villages that offered employment in local industry. This restricted hunting activities of the men to some extent, and wages allowed them to buy more imported foods.

Cesium-137 in Native Foods.

Cesium-137 concentrations in caribou and reindeer flesh were nearly similar; both were many times thoseo f other native foods. Anaktuvuk Pass animals consistently contained higher values than animals from other locations (Table 3).

Cesium-137 was not detected in most samples of native foods other than caribou and reindeer. Marine mammals occasionally contained detectable Cs^{137} concentrations, but the levels were 25 to 100 times less than those of caribou from the adjacent land area, as were fish from a lake near Barrow. Cesium-137 was not detected in similar fish from nearby rivers, lagoons, or in the marine fish obtained at other locations.

Radionuclide concentrations in ptarmigan consistently exceeded those in marine eiders and murres. Ptarmigan eat large amounts of willow leaves and buds which provide a direct source of adsorbed Cs^{137}. Marine birds usually contained undetectable or very low amounts of Cs^{137} because of dispersion of fallout occurring over oceans and the low concentration of Cs^{137} relative to stable cesium in marine waters (Davis, 1963) makes it relatively unavailable for assimilation in appreciable amounts.

Berries and leaves of certain plants were utilized by the Eskimos to varying degrees. Cesium-137 levels in these foods were occasionally detectable, but the contribution to the total Cs^{137} intake was negligible. A similar situation pertained to domestic foods. Hard wheat flour, condensed milk, and powdered milk obtained from native stores

TABLE 3. CESIUM-137 CONCENTRATIONS IN CARIBOU FLESH OBTAINED FROM NATIVE SOURCES DURING 1962 AND 1963.

Location	Cesium-137 concentration (picocuries per gram wet weight) 1962	1963
Anaktuvuk Pass	9.1	19
Fort Yukon	—	7.6
Point Hope	2.8	4.9
Barrow	2.2	4.3

contained Cs^{137} concentrations considered typical of domestic foods and similar to those reported in comparable Finnish Lapps' diets (Miettinen, *et al.,* 1963).

DISCUSSION AND CONCLUSIONS

Results of this study are remarkably similar to those reported in a study of Finnish Lapps (Miettinen, *et al.,* 1963) and illustrate the important effect of environmental factors upon food habits and subsequent Cs^{137} concentrations in Arctic animals. Greatest Cs^{137} body burdens consistently occurred in people whose diet was predominantly caribou or reindeer compared to those who ate other foods; in people who practiced storage and year-round consumption of caribou or reindeer compared to those who ate it seasonally; in terrestrial animals compared to aquatic animals; and in lake fish compared to those from streams, lagoons, or oceans. Similar observations have been reported in plants and animals of northern Alaska (Watson, Hanson, and Davis, 1963) and in Norway (Kummeneje, 1962a and 1962b), and in fish from Alaska (Watson and Rickard, 1962) and Finland (Häsänen and Miettinen, 1963).

Although the Finnish Lapp and Alaskan Eskimo-Indian populations studied are culturally quite different, certain ethnic groups within these populations contained comparable Cs^{137} body burdens which were proportional to their caribou or reindeer consumption rate. Alaskan Eskimos' estimates of meat consumption were generally greater than those of Finnish Lapps; however, greater Cs^{137} concentrations in Finnish reindeer (7 to 18 picocuries per gram wet weight) than in Alaskan caribou and reindeer (1 to 10 picocuries per gram wet weight) during comparable periods tended to equalize the Cs^{137} intake by humans.

Local non-Lapps in the Finnish study and non-native residents of Alaskan villages usually contained much lower body burdens than native residents, the difference being proportional to caribou-reindeer consumption. Average Alaskan values were 5.2 and 7.9 nanocuries at Barrow, and 48 and 41 nanocuries at Kotzebue during 1962 and 1963, respectively. The Barrow values resemble those of people of the other United States and in Japan (Yamagata, Kodaira, and Hayami, 1962), while those of Kotzebue were similar to those of residents of Bergen, Norway (Madshus, Strømme, and Koren, 1963).

During 1963, three non-native residents of an Alaskan river village who had eaten unusually large amounts of caribou meat during fall, winter, and spring months, and fish almost exclusively during the summer, contained Cs^{137} body burdens about five times those of native residents at the same location. Their estimated caribou meat consumption was about five times that of the average river village Eskimo.

The occurrence of higher Cs^{137} body burdens among the 20-50 age group, and in men, is the result of caribou-reindeer consumption rate and physiological phenomena. This age group consumed more caribou and/or reindeer than children or elderly people, and men ate about fifty per cent more meat than women. Men also contained a greater amount of muscle, in which Cs^{137} concentrates. Also, children appear to physiologically discriminate against cesium in favor of potassium (Onstead, Oberhausen, and Keary, 1962).

Cesium-137 body burdens in native children who attended boarding schools distant from their home villages were slightly lower than those of their brothers and sisters who attended local schools and ate caribou and reindeer typical of their family diet. This resulted from their change to a diet which included little or no caribou or reindeer for about nine months each year, during which their Cs^{137} was presumably reduced at a biological half-life of about 45 to 75 days (Miettinen *et al.*, 1963; Rosoff, Cohn, and Spencer, 1963).

High Cs^{137} concentrations in caribou and reindeer flesh are a natural consequence of the animals' preference for lichens, especially during fall and winter months when those plants are moist and more available than other plants (Scheffer, 1951; Herre, 1955; Makhaeva, 1959). Lichens usually contain greater amounts of most fallout radionuclides, especially Cs^{137}, than other plants in the same general area (Gorham, 1959; Hvinden and Lillegraven, 1961; Watson and Rickard, 1962). Increased Cs^{137} concentrations in caribou flesh during 1963 were the result of nuclear weapons tests conducted principally by Russia and the United States during 1961 and 1962. Current Cs^{137} values in Alaskan caribou flesh are appreciably lower than those in a limited number of similar samples from northern Canada (Canadian DNHW, 1963), in which there was some evidence of increasing Cs^{137} values as one moved from the west in an easterly direction. A similar corollary might be made from our values in Table 3; however, we have previously noted a tenfold difference in Cs^{137} concentrations in flesh samples from two reindeer herds maintained in different environments near Kotzebue during 1962 (Hanson, Palmer, and Griffin, 1964). Likewise, Alaskan caribou samples from the Cape Thompson region contained appreciably lower Cs^{137} concentrations than those obtained from other regions during 1960 and 1961 (Committee on Environmental Studies for Project Chariot, 1962). The difference in values is believed to be related to the availability of lichens for forage in the various areas and varient Cs^{137} concentrations in lichen species.

During 1962, four persons at Point Hope who had eaten moose meat during a short period prior to being counted, contained greater amounts of Cs^{137} than other village residents. This prompted the 1963 investigations of Cs^{137} levels in the Fort Yukon residents and collection of both moose and caribou from the same range. Preliminary results indicate that moose contain substantially lower Cs^{137} concentrations (one-third to one-thirtieth) compared to caribou, the degree of difference depending upon seasonal food habits of the animals.

Radiological health considerations of the human Cs^{137} body burdens reported in this study have been extensively discussed elsewhere (cf., p. 802-817 and p. 1126-1132, U. S. Congress, Joint Committee on Atomic Energy, 1963). It is generally agreed the amounts we have measured are well within radiation exposure limits proposed by recognized authorities. The International Committee on Radiological Protection (1955) recommends that the maximum permissible body burden of Cs^{137} be set at 3,000 nanocuries for individuals in the population at large who are not exposed in the course of their occupation. No specific recommendation was made concerning average levels of Cs^{137} for groups such as the Alaskan Eskimos.

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DISCUSSION

DISCUSSION LEADER ROBINSON: This subject is always good for a lively discussion. You said that the radiation level was safe with respect to humans. Now, could you elaborate on that radiation level with respect to caribou and reindeer?

MR. HANSON: The discussion of this is really very difficult. We talk about exposures of people rather than whether or not they are up to or under a limit. The Federal Radiation Council, as one can see over here in this Fallout In Perspective exhibit by the Atomic Energy Commission, states that the 30-year gonad dose of ionizing radiation is 5 rem. This is just a unit that we use conveniently, for thirty years. The people of Alaska, if they have this average amount that I reported here, would come up in thirty years to 2.3 rem, which is slightly less than half as much as the radiation protection guides state.

Natural background is going to produce about 7 to 15 rad in a lifetime. This is the average estimate, and the cosmic rays of terrestrial radiation—and you and I all have some radioactivity in us from the potassium in our bodies, of which we have about a quarter of a pound. A small amount of that is naturally radioactive, and these sources contribute about a hundred millirem per year. The people at Anaktuvuk Pass are receiving about 78, or less than you get from natural background, from the cesium within their bodies.

The amounts of cesium in the caribou are very difficult to estimate. There is some discrepancy among research data at the present time as to whether or not cesium is uniformly distributed through the body or whether it is higher in some types of muscle than in others, or in other organs. But if we take the published constituents of the body percentage-wise that are accepted generally as the standard man, the standard American man, and divide them into these amounts that we have found, we come out with a very comparable value in both caribou and humans. The wolf tends to be just a little bit higher on the basis of a few samples, a very few samples. We are now investigating this even further, to find out just exactly what is the level in the caribou, in the wolf, and in man, and to see if we can make some comparison here.

But it is generally agreed that the amounts, either to the caribou or to the humans in Alaska, are not of great importance. It hasn't reached a point where it is even doubling the amount we obtain from natural sources of radiation, and this we know would be a very tenuous thing. We know it would be very difficult to even see any changes.

If there would be any effect upon the caribou, certainly the first thing would be genetic effect. And I think probably most of you have some appreciation of how difficult it is to conduct a genetic study of something up in the millions of animals that are needed. And how are you going to hold time still during this time to show that a change that you may see hasn't been due to things other than just the radiation?

DR. VINCENT SCHULTZ (Mount Airy, Maryland): I would like to break in with an announcement that concurrently with Mr. Hanson's excellent presentation there is a session being held on Radiation in Wildlife, and you can get comparative data on American species. If you are interested, you are welcome. The program is posted over on the display if you want to see who the specific speakers are and what they are going to talk about.

Thank you.

DR. DAVID R. KLEIN (Alaska Cooperative Wildlife Unit, College, Alaska): I wonder if you could tell us what the comparative levels of Cesium 137 are in lichens versus the summer feeds of caribou, such as sedges and possibly willows, and possibly whether there have been any plant physiological studies to show the mechanism of incorporation or accumulation of Cesium 137 in lichens.

MR. HANSON: This is very difficult, Dr. Klein. I will be glad to discuss this wth you later.

Roughly I can tell you this, that the lichens, the mosses, are generally fairly close together, and many times that of any of the other species. Willows are deciduous and therefore we don't have this accumulation over several years, several seasons of fallout, and therefore they are very, very low compared with the lichens. The lichens themselves are of several orders of magnitude higher than other types of plants.

As to the plant physiology, I wouldn't want to discuss it. There is a fluctuation back and forth. The ratios of, say, Cesium to Strontium in fallout are taken at 1.7. We get into these plants and sometimes it goes up as high as 10 and sometimes as high as 100, so there is evidently a differential mechanism going on here. We don't understand it, and we think this can be done only not through field studies but through very closely controlled laboratory studies.

HYPOGONADISM IN WHITE-TAILED DEER OF THE CENTRAL MINERAL REGION IN TEXAS[1]

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This investigation was initiated to gather information on large numbers of male deer (*Odocoileus virginianus texanus*) suffering from hypogonadism in the Central Mineral Region in Texas.

A review of literature indicated that other investigators mentioned this phenomenon in various species of *Odocoileus* in the United States and that it was considered rare (Clarke, 1916; Clark, 1953; Linsdale and Tomich, 1953; Weston, 1954; Severinghaus and Cheatum, 1956;

[1]This is a contribution of a cooperative research project between the Texas Parks and Wildlife Department and the Department of Veterinary Pathology, Texas A&M University financed by Texas Pittman-Robertson Project W-90-R.

Figure 1. Male Deer (with Collar) Suffering from Hypogonadism

Lang, 1957; Jenkins and Bartlett, 1959; and Robinette and Jones, 1959).

The Central Mineral Region covers approximately 2 million acres and is a basin 200 to 800 feet lower than the limestone soils of the surrounding Edwards Plateau. The region was formed when igneous intrusions of pre-Cambrian origin weathered away faster than the limestone of the Edwards Plateau leaving a basin where the upthrust had once been a highland (Sellards *et al.,* 1932).

The soils, climate, and vegetation of the region have been previously described or reviewed by Carter (1931), Hahn (1945), Walker (1949), Thomas, Teer, and Walker (1963), and Teer (1964).

Male deer suffering from hypogonadism were recognized on gross examination by the following characters: testicles approximately one-sixth the size of normal males during the breeding season; feminine body proportions; and antlers that retain the velvet during the breeding season and were usually of abnormal formation (Figure 1). Ranchers and hunters referred to deer suffering from hypogonadism as "velvet-horns." We will use this term throughout the remainder of this paper.

Llano County, comprising 606,000 acres, located in the heart of the Central Mineral Region, was chosen as a study area. Data on the num-

TABLE 1. NUMBERS OF VELVET-HORN BUCKS KILLED IN LLANO COUNTY AS COMPARED TO TOTAL BUCKS KILLED, 1959-1962

Year	*Total Buck Kill*	*Velvet-Horns Killed*	*Per cent Velvet-Horns*
1959	5,214	143	2.7
1960	6,045	406	6.7
1961	7,099	441	6.2
1962	3,480	328	9.4

ber of velvet-horns killed during the regular hunting seasons were available from check station records for 1959 and 1960 and from records kept by landowners for 1961 and 1962.

OCCURRENCE

The number of velvet-horns killed during the November 16-December 31 deer hunting seasons of 1959 through 1962 is compared to the total buck kill in Table 1.

Approximately 2,000 male deer were examined from the areas of the Edwards Plateau immediately adjacent to the central Mineral Region during the study period. None was found to be suffering from hypogonadism.

HYPOGONADISM RELATED TO SOILS TYPE

The approximate location of each velvet-horn killed in Llano County was plotted on soils maps. These maps revealed that the majority were killed on a particular soils type. This soils type is in the Tishomingo series and is subclassed as "gravelly sandy loam" (Anon., 1962). It is locally called granite gravel. Soils of this type comprise 30-40 per cent of the land in Llano County. The deer population, which varied from 145 deer per square mile in 1959 to 78 deer per square mile in 1962, and deer kill were quite homogeneously distributed over the southern two-thirds of the study area. The number of velvet-horns killed on granite gravel soils are compared to those killed on non-granite gravel soils in Table 2.

Studies on the home range of the non-migratory deer of the region revealed that deer had a maximum home range with a radius of 1½

TABLE 2. VELVET-HORN KILL IN GRANITE GRAVEL AREAS COMPARED TO KILL IN NON-GRANITE GRAVEL AREAS

Year	Total Killed	Kill on Granite Gravel Areas		Kill on Non-Granite Gravel Areas	
		Number	Per Cent	Number	Per Cent
1959	143	130	90.9	13	9.1
1960	408	372	91.6	34	8.4
1961	441	392	88.9	49	11.1
1962	328	311	94.8	17	5.2
Total	1,318	1,205	91.4	113	8.6

miles (Hahn, 1945; Hahn and Taylor, 1950; and Thomas, Teer and Walker, 1964).

This indicated that even though some of the velvet-horns were not killed on granite gravel soils, most of them were killed near enough to granite gravel areas so that these areas were probably included in their home ranges (Figure 2). There was a definite correlation between soils type and the occurrence of velvet-horns.

EFFECT OF HYPOGONADISM ON HERD REPRODUCTION

In order to test the effect of hypogonadism in male deer on herd reproduction, available data gathered using the Hahn Cruise Line Technique (Hahn, 1949) for the years 1954-1962 were analyzed (Unpublished data, Texas Pittman-Robertson Project W-62-R).

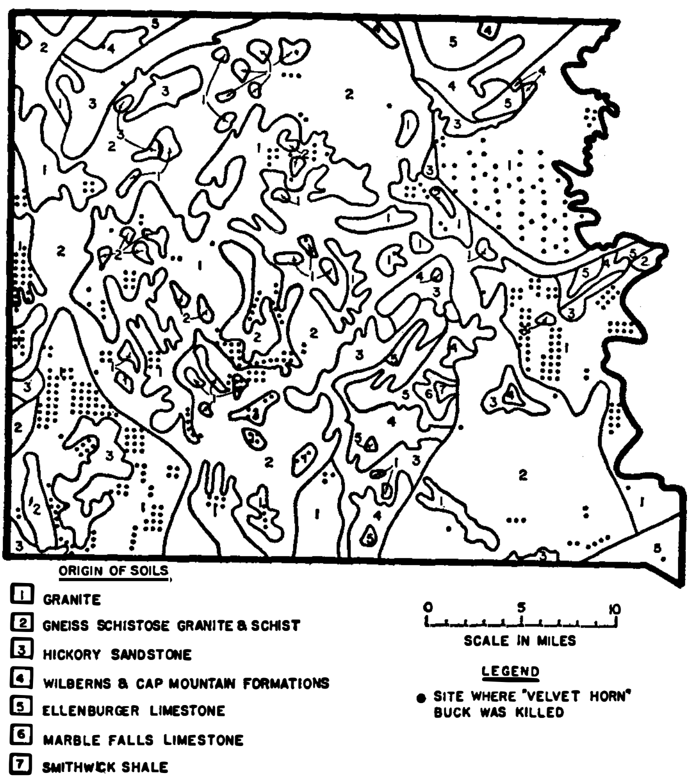

Figure 2. Distribution of the Location of the Kills of Male Deer Suffering from Hypogondaism as Related to Soils Types, Llano County—1961 Deer Hunting Season (Considered to be typicalo f the kill distributions for the 1959, 1960, and 1962 deer hunting seasons.)

For comparative purposes the Llano County study area was divided into two portions; granite gravel soils areas, where velvet-horns were common, and non-granite gravel areas, where velvet-horns were rare or absent.

The 32 two-mile Hahn cruise lines located in Llano County were plotted on soils maps and ten lines laid out entirely in granite gravel areas were selected for comparison to ten lines laid out entirely in non-granite gravel areas.

The data available from two counts made on each of these lines in September and October of the years 1954 through 1961 were analyzed to derive a measure of reproduction as indicated by the ratio, fawns per 100 does. These ratios were compared between these soils types for each year. These data are shown in Table 3.

This measure of reproduction followed the same basic pattern on granite gravel and non-granite gravel soils. These data were statistically analyzed for each year (using 2 by 2 Chi-Square tables). The tests revealed no significant differences in reproductive performance between soils types for the years tested ($P = 0.05$).

Uteri and ovaries were collected from female deer in Llano County during the regular hunting seasons of the years 1957 through 1961 in the process of deer reproductive studies conducted under the direction of James G. Teer, Texas Pittman-Robertson Project W-62-R (Teer, 1964). Gross examination of 2,469 tracts revealed no involvement of the reproductive systems similar to that observed in velvet-horns.

The tracts collected in 1959, 1960, and 1961 were divided into those collected on granitic soils and on non-granitic soils. Tracts from ranches that lay astride transition zones between the two soils types were eliminated from consideration.

The "ovulation incidence" or average number of corpora lutea per ovulating female was derived for the comparative samples using the

TABLE 3. FAWNS PER 100 DOES—COMPARING REPRODUCTION ON GRANITE GRAVEL AND NON-GRANITE GRAVEL AREAS

	Soils Areas					
	Granite Gravel Areas			Non-Granite Gravel Areas		
	Deer Observed		Fawns per	Deer Observed		Fawns per
Years	Does	Fawns	100 Does	Does	Fawns	100 Does
1954	224	92	41.1	167	60	35.9
1955	189	33	17.5	158	28	17.7
1956	180	95	52.8	144	69	47.9
1957	185	49	26.5	208	54	25.9
1958	155	174	112.2	171	152	88.9
1959	162	140	86.4	236	187	79.2
1960	223	160	71.7	176	100	56.8
1961	294	111	37.8	273	122	44.7
1962	167	63	37.7	130	37	28.5

gross technique described by Cheatum (1949). These data are shown in Table 4.

Statistical analysis of the reproductive data (*t* test; $t = 0.05$) revealed no significant differences between the "ovulation incidences" of the comparative samples for the years tested.

Golley (1957) pointed out that bodies resembling corpora albicantia may arise from several sources other than current regression of corpora lutea of pregnancy. In view of this we made no effort to base our analysis of reproductive performance on the number of corpora albicantia present, but considered the presence of corpora albicantia as an indication of pregnancy during the breeding season prior to collection. This measure of reproduction was expressed as the per cent of the collection that had corpora albicantia present in the ovaries. These data are shown in Table 4.

Statistical analysis of these comparisons (*t* test; $P = 0.05$) revealed no significant difference in the percent of tracts collected with evidence of pregnancy in the preceding season between soils types for the years tested.

PATHOLOGICAL OBSERVATIONS

Tissues were obtained from 30 velvet-horns during the months of November, December and January and preserved in 10 per cent buffered formalin. Gross observations of the antlers and other organs were made at the time of collection. The fixed tissues were dissected free of extraneous material and photographed. The individual reproductive organs were weighed, and tissue blocks were cut from various organs, imbedded in paraffin and sectioned at six microns. Frozen sections were prepared on a cryostat and sectioned at 10 microns for staining with Oil Red O and Diazo Blue B. The paraffin sections were routinely stained with hematoxylin and eosin. Periodic acid-Schiff stains were employed in selected cases to demonstrate basement membranes.

Serum samples were tested for anaplasmosis using the complement

TABLE 4. COMPARISON OF REPRODUCTIVE PERFORMANCE OF ADULT FEMALES BETWEEN SOILS TYPES AS INDICATED BY REPRODUCTIVE TRACT COLLECTION.

Year	Type of Soil	Total Collected	Containing Corpora Lutea	Corpora Lutea Present	Ovulation Incidence	Containing Corpora Albicantia	Per Cent with Corpora Albicantia
1959	Granite	107	85	137	1.61	84	78.5
	Non-Granite	167	103	157	1.52	146	87.4
1960	Granite	91	75	112	1.49	63	69.2
	Non-Granite	132	104	138	1.32	89	67.4
1961	Granite	72	39	50	1.28	52	72.2
	Non-Granite	94	49	69	1.40	76	80.9

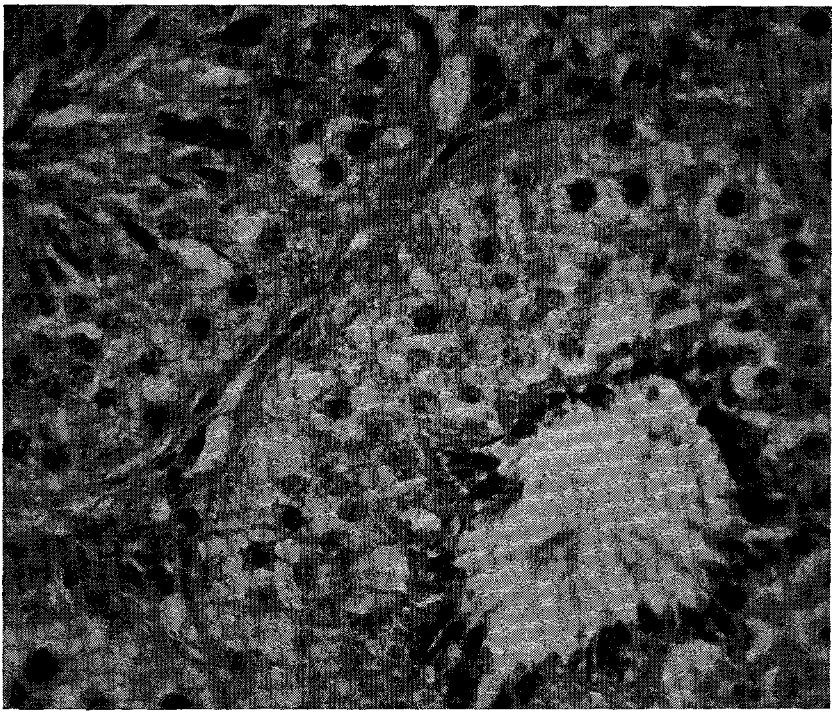

Figure 3. Seminiferous Tubules of Male Deer, Collected in Mid-November, Suffering from Hypogonadism. Hematoxylin and Eosin, 600X. (The dense cellular interstitial tissue and small atrophic tubles are easily seen.)

fixation test; brucellosis using the plate agglutination method; and for two serotypes of *Leptospira* using the micro-agglutination lysis test.

The tests collected from velvet-horns were small and the epididymides were relatively larger due to the diminution in the size of the testes. Deer with regressed testicles were in excellent body condition, as reflected by body fat deposits, in contrast to normal males who visibly lost weight during the rutting period. No gross lesions indicative of systemic change were present in any organ except the testes.

The testes of velvet-horns contained small involuted tubules. These tubules had light hyaline centers usually devoid of cells and were surrounded by thick cellular connective tissue.

The most abundant tissue in the regressed testes was fibrous connective tissue, and the amount of tissue indicated some proliferation, in addition to thickening produced by contraction of the organ (Fig 3). Periodic acid-Schiff stain revealed the basement membranes to be thickened and convoluted indicating a reaction to the loss of the tubular epithelium.

In three of the testes, cells were present inside the tubular lumens and had proliferated to form adenomatoid structures. These cells could be traced to their origins from Sertoli cells. They contained prominent nucleoli, had acidophilic foamy cytoplasm, and took similar characteristics to interstitial cells. Oil Red O did not stain the interstitial cells of the involuted testes well, and the intensity of staining was noticeably less than in normal testes subjected to the same stain.

One regressed testis contained clumps of interstitial cells which were stained more intensely by Oil Red O than those of other deer. This deer bore antlers from which the velvet was shed, but the antlers were not polished. Staining with Diazo Blue B paralleled the results obtained with Oil Red O.

The atrophied tubules in the testes of seven deer contained mineralized bodies which were particularly abundant in two of these deer.

Figure 4. Seminiferous Tubules of a Normal Male Deer in Mid-November. Hematoxylin and Eosin, 600X. Full Production.

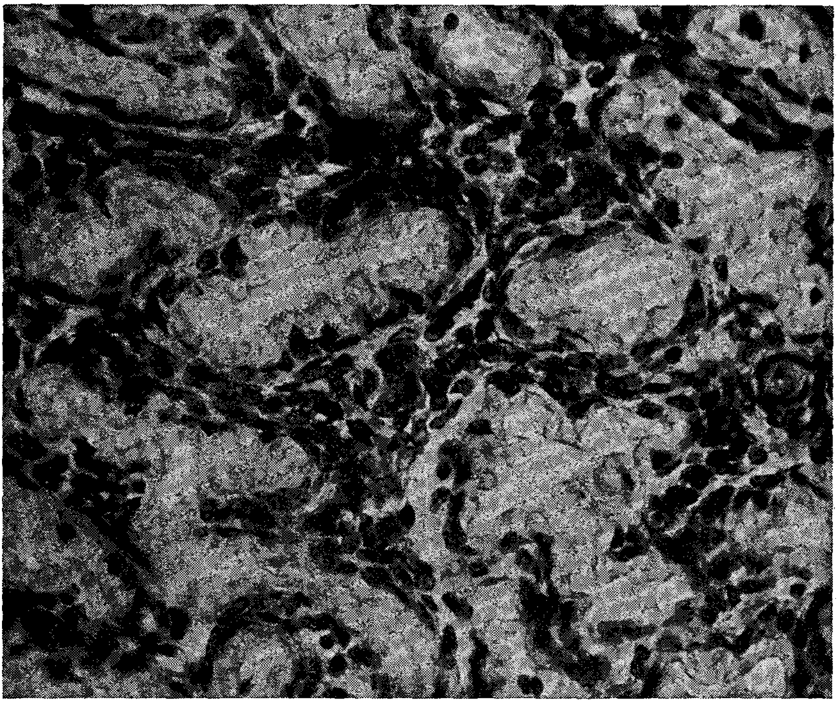

Figure 5. Seminiferous Tubules of a Normal Male Deer in Mid-May. Hematoxylin and Eosin, 600X. Period of Sexual Rest. Spermatogenic inactivity.

Sections of the pituitary glands of the deer revealed enlarged, hydropic cells in six deer. These cells are termed "castration cells." No histopathological change was observed in the adrenal glands of the affected deer.

Comparison of the atrophied testes to normal testes collected during the same period (Figure 4) and during the period of reproductive quiescence (Figure 5) indicated that the tubules of the deer suffering from hypogonadism were more involuted than any state of the normal reproductive cycle. None of the velvet-horns examined were capable of reproduction.

Although the functional mass of Leydig cells was reduced severely, some activity remained, as indicated by the special straining procedures given earlier. That this activity of the interstitial cells remained at all indicated that the primary damage to the testicle was to the sperm producing epithelium, with secondary, variable, and incomplete atrophy of the testosterone-producing elements.

Three specialized types of cells are removed in surgical castration;

the spermatogenic cells, the cells of Leydig, and the Sertoli cells. Deer respond to surgical castration by retention of the velvet and antlers (Wislocki, Aub and Waldo, 1947; Gaskoin, 1856). These changes persist unless endocrine therapy or freezing of the antlers alters the progression of these manifestations. (Wislocki, Aub and Waldo, *op. cit.*) The "velvet-horn syndrome" did not readily compare to the changes seen in surgical castration, for the specialized cell types, particularly interstitial cells and Sertoli cells, persisted in variable quantities. Both of these cell types were capable of hormone production. Production of variable amounts of circulating androgens resulted in the variable response observed in the pituitary glands of the deer; levels of androgen in some individuals were so low as to produce the "castration cells" as described by Turner (1955).

The lack of inflammatory reaction in the affected testes indicated that this was not an infectious process. Nevertheless, serological work was done on the blood serum of the deer for detection of *Brucella ovis, B. abortus, Leptospira pomona, L. icterohaemorrhagiae,* and *Anaplasma marginale.* These tests were consistently negative.

At present, there are no known dietary factors which specifically affect spermatogenesis in domestic animals; diets which are adequate for growth and maintenance are adequate for full fertility (Jubb and Kennedy, 1963).

It was the hypothesis of Taylor, Thomas and Marburger (1964) that dietary deficiencies were a possible cause of the hypogonadism. Later experience has led us, in view of the otherwise excellent condition of the entire animal, to exclude dietary deficiency as a probable cause.

Investigations are now underway to determine possible toxic agents occurring on the granite gravel soils type which may be gonadotoxic.

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DISCUSSION

MR. VIRGIL HUNT (Sequoia-Kings National Park): I noticed in taking a herd composition count of our migratory California mule deer this year we have an extremely high incidence of what appear to be velvet-horn bucks. I would say that in classifying or counting about 225 animals at least 18 during the rut would follow the descriptions you listed there. So if that is true, then this thing is found not only in Texas, but we have got it too.

DR. R. M. ROBINSON: I think that this is very interesting. We have in the library search found many scattered reports of isolated instances of what they term in Utah and Arizona "cactus bucks." We think that these changes are similar, if not the same as we observed in a more massive amount here in this particular region of Texas.

DR. KLEIN: I was wondering if you had the opportunity to observe the behavior of these velvet-horn bucks, particularly during the rutting season. Also, were you able to see any differences in the chemical analyses of the soils of this area versus other areas?

MR. THOMAS: We have submitted a manuscript to the *Journal of Mammalogy* on altered behavior patterns of deer of this type. The behavior is severely altered. They are below all adults and below some yearlings and some aggressive fawns in the "peck order." They tend to remain together in groups throughout the twelve-month period of the year. From this brief description you can tell that their behavior is severely altered.

We have collected soil samples between the two studied areas, but we have no results from the soil analysis yet.

MR. DON J. NEFF (Arizona Game and Fish Commission, Prescott, Arizona): You say in your paper that there was no known nutritional deficiency which would cause this. Do you know of any mineral which might be in the soil which you might suspect as causing this kind of thing? Has any such effect ever been noted?

DR. R. M. ROBINSON: We have in our search of the literature found no mineral which occurs naturally in the soil which will occur as a specific gonadotoxin. I might add that we have discovered some things which, when injected experimentally, will produce severe testicular atrophy. Experimentally, some dificiencies will produce testicular atrophy, but these deficiencies are accompanied by other changes in the organism which we do not find in these velvet-horn deer.

Notable among these substances which will produce testicular atrophy are almost but not lethal quantities of cadium chloride This is not found naturally, I believe, in our soil. Erucic acid will do this in rats. Erucic acid is found in great quantities in mustard seed, rape seed or nasturtium seed. The problem of whether this particular substance occurs in this area has not been worked out.

Some of the anthracine derivatives from coal tar will also produce specific testicular atrophy. These substances are not considered very likely in this area. We don't have coal in the Central Mineral Region.

WINTER WEIGHTS OF NORTHERN YELLOWSTONE ELK, 1961-62

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National Park Service, Yellowstone National Park, Wyoming

Various weights were obtained from more than 1,100 Rocky Mountain elk *Cervus canadensis* removed from the Northen herd of Yellowstone National Park during the winter of 1961-62. The reasons for and methods of removal have been reported by Rush (1932), Grimm (1939), Kittams (1946-58, 1953) and Howe (1962). This large sample provided an opportunity for more detailed analyses and greater refinement of the various weight relations than were previously reported by West (1941), Skinner (1946), Quimby and Johnson (1951), Murie (1951) and Wright (1956).

A 500-pound capacity Chatillion spring scale suspended from the 15-foot boom of a hoisting truck was used for weighing carcasses. The animals were neck chained to facilitate lifting them free of the ground. Body weights obtained from mid-December to mid-February were recorded to the nearest 5 pounds. Approximately one-half of the carcasses were completely eviscerated and also had the feet removed, while the other one-half had only the rumen, intestines, kidneys, uterus, mammae and external genitilia removed. Very few whole or hunter dressed (eviscerated only) carcasses were available. Field inspection of mandibular teeth provided for age classification of calves, yearlings and 2-year-olds based on replacement of permanent teeth. Wear on the mandibular check teeth was used for classification of older animals into a 3-thru-7-year group and an 8-year-and older group (Quimby and Gaab, 1957). This oldest age group contained a predominant number of 10-to-20-year-old animals.

During January and February, weights were obtained to the nearest pound for 414 sets of chest viscera and for 324 sets of feet (Table 1). These weights have also been rounded off to the nearest 5 pounds to facilitate their comparison with hunter dressed weights (Table 2). Most were obtained at a processing plant but a few were secured in the field. Chest viscera included trachea, heart, lungs, diaphragm and liver. The feet were removed at the processing plant by sawing through the general area of the carpal and tarsal bones. Field weights of feet disarticulated at joints were similar to those from the plant. Differences between chest visceral weights (nearest 5 pounds) for the sexes did not appear for any age class during Jan-

TABLE 1. THE MEAN WEIGHTS (POUNDS) OF 414 SETS OF CHEST VISCERA (SEE TEXT) AND 324 SETS OF FEET OBTAINED DURING 1962.

	Viscera						Feet		
	January 19–31			February 2–15			January and February		
	No.	Mean	Nearest 5 lbs.	No.	Mean	Nearest 5 lbs.	No.	Mean	Nearest 5 lbs.
Calf-Unk.	16	11 (6–12)	10	3	11 (10–13)	10	7	8 (7–10)	10
Calf ♂	7	12 (9–15)	10	—	—	—	5	11 (8–12)	10
Calf ♀	6	12 (9–18)	10	21	11 (6–17)	10	23	8 (7–11)	10
1½♂	8	15 (13–18)	15	7	16 (12–19)	15	11	12 (11–13)	10
1½♀	4	15 (13–16)	15	19	13 (10–16)	15	18	10 (8–13)	10
2½♂	2	20 (16–24)	20	13	19 (13–23)	20	16	13 (10–15)	15
2½♀	11	18 (13–20)	20	24	17 (13–23)	15	27	11 (9–13)	10
3–7♂	10	21 (14–27)	20	14	25 (16–30)	25	20	15 (11–17)	15
3–7♀	71	21 (14–28)	20	115	20 (19–26)	20	145	11 (9–16)	10
8+♂	2	21 (19–23)	20	3	25 (21–30)	25	5	15 (10–16)	15
8+♀	16	22 (19–27)	20	42	20 (14–28)	20	47	12 (10-14)	10
Total									
♂	29			37			57		
♀	108			221			260		
Unknown	16			3			7		

uary (Table 1). The February samples show weights for females of the three oldest classes to be 5 pounds less than for males. Actual mean feet weights did not vary between months. Weights for females were 2 to 4 pounds less than for males in all age classes. This difference shows only for the three older groups when rounded off to the nearest 5 pounds.

HUNTER DRESSED WEIGHTS

Males.

Hunter dressed weights were obtained for 271 males (Table 2). The earliest weekly mean weights were usually largest in each age class and weights for each following week generally decreased. Regressions were prepared for each age class. During the 10-week period, mid-December to mid-February, all age classes had an average weekly loss of weight as follows: calves, 6¼ pounds; yearlings, 2¾ pounds; 2-year-olds, 7¾ pounds; 3-thru-7-year olds, 6¼ pounds; and 8-years-and-older, 8½ pounds. All regression lines are significant (Table 3).

Samples were inadequate during some weeks, therefore the following monthly groupings have been made: December (2 weeks, December 11 to 23, 1961), January (5 weeks, January 1 to February 3, 1962) and February (2 weeks, February 5 to 17, 1962). No animals were available during the week of December 24 to 31. These groupings permit additional evaluations that are not evident from the 10-week regressions or seasonal means.

Monthly mean weights indicate the yearlings and 8-year-and-older group had a significant 10 and 12 per cent weight change during the season (December to February) but the yearlings lost only half as

TABLE 2. HUNTER DRESSED WEIGHTS (NEAREST 5 POUNDS) OF MALE AND FEMALE ELK DURING THE WINTER OF 1961–62.

		December				January				February				Season			
		No.	Mean	SD	Range	No.	Mean	SD	Range	No.	Mean	SD	Range	No.	Mean	SD	Range
Calf																	
Male		4	218	±32	190–250	30	169	±28	135–245	7	165	±21	135–195	41	173	±30	135–250
Female		4	161	± 6	155–170	43	150	±23	90–185	7	161	±26	110–190	54	152	±22	90–190
Yearling																	
Male		16	281	±35	210–335	45	274	±26	210–330	14	254	±29	205–295	75	272	±30	210–335
Female		8	256	±45	185–305	51	246	±28	190–335	24	245	±28	220–340	83	247	±30	185–340
Preg.		—	—			3	273		260–295	—	—			3	273		260–295
Non-preg.		5	262		185–209	23	250		210–335	12	255		220–340	40	253		185–340
2-yr.-olds																	
Male		21	391	±57	290–490	25	345	±47	260–425	12	341	±26	290–380	58	361	±52	260–490
Female		16	349	±40	255–410	59	307	±37	195–385	51	317	±40	240–410	126	316	±41	195–410
Preg.		8	359		330–395	37	312		255–385	28	319		240–370	73	320		240–395
Non-preg.		1	255			—	—			2	288		270–305	3	277		255–305
3-thru-7-yrs.																	
Male		31	449	±44	365–535	29	409	±33	325–480	11	402	±48	345–490	71	425	±45	325–535
Female		34	363	±52	240–460	181	345	±45	185–450	122	337	±34	265–430	337	344	±43	185–460
Preg.		25	381		310–460	115	347		185–445	72	338		265–430	212	348		185–460
Non-preg.		3	262		240–280	9	310		295–375	1	355			13	302		240–375
8-yrs.-and-older																	
Male		7	461	±30	420–500	12	430	±74	260–510	7	407	±55	335–510	26	432	±62	260–510
Female		24	362	±48	260–435	134	340	±43	235–445	98	337	±41	225–430	256	341	±43	225–445
Preg.		11	368		290–435	79	345		265–445	57	346		250–430	147	347		250–445
Non-preg.		5	338		325–380	16	324		235–420	12	304		225–365	33	319		225–420
TOTALS:																	
Male	271																
Female	856																
Preg.	435																
Non-preg.	89																

TABLE 3. REGRESSIONS OF HUNTER DRESSED ELK WEIGHTS FOR A 10-WEEK PERIOD IN THE WINTER OF 1961–62.

	Males				Females			
	Regression	s_b	t-value	df	Regression	s_b	t-value	df
Calf	y = 213.66 − 6.132 X	2.313	−2.650*	39	y = 150.11 − 0.317 X	1.428	0.222	52
Yearling	y = 288.51 − 2.674 X	1.175	−2.275*	73	y = 260.86 − 1.970 X	1.412	−1.397	81
2-year-old	y = 410.82 − 7.786 X	1.896	−4.106*	56	y = 336.05 − 2.816 X	1.334	−2.110*	124
3-thru-7	y = 458.37 − 6.318 X	1.449	−4.361**	69	y = 374.32 − 4.251 X	0.935	−4.548**	334
8-year-and older	y = 480.12 − 8.376 X	3.534	−2.350*	24	y = 376.83 − 4.820 X	1.126	−4.279**	254

* significant at 5 per cent level.
** significant at 1 per cent level.

many pounds as the older group (Table 4). The yearlings lost 7 pounds (3 per cent) during the first half of the season (December to January) and 20 pounds or 7 per cent during the last half of the season (January to February). The latter was significant at the 5 per cent level. The 8-years-and-older group had a weight loss of 31 and 23 pounds respectively for the first and last half of the season, and a seasonal decline of 54 pounds (12 per cent). Only the latter was significant.

The remaining classes (calf, 2-year and 3-years-and-older) had almost all of their declines in weight during the first half of the season and each is significant at a 1 per cent level. Minimal losses occurred during the last half of the season for each class. Seasonal weight loss of approximately 50 pounds for each age class indicated twice the percentage loss for calves as compared to 2-year-olds, 3-thru-7-years as well as the 8-year-and-older class.

Females.

The 856 female weights provided regressions for each age class. Losses were less than for respective males. The average weekly loss during the 10-week period was as follows; yearlings, 2 pounds; 2-year-olds, 2¾ pounds; 3-thru-7-year-olds, 4¼ pounds and 8-years-and-older, 4¾ pounds. The calf and yearling regressions were not significant, but those for the three older age classes were (Table 3). Female calves showed a very slight increase in weight during the period.

Monthly means indicate a positive weight change for the calves and 2-year-olds from January to February (Table 4). The respective

TABLE 4. DIFFERENCES BETWEEN MEAN HUNTER DRESSED WEIGHTS OF ELK FOR DIFFERENT PERIODS OF THE 1961–62 SEASON.

Age and sex	Weight differences December to January			Weight differences January to February			Weight differences December to February		
	No.	Pounds	Per cent	No.	Pounds	Per cent	No.	Pounds	Per cent
Calf									
Male	34	49[1]	22.5**	37	4	2.4	11	53	24.3**
Female	47	11	7.4	50	+11	7.3	11	0	—
Yearling									
Male	61	7	2.5	59	20	7.3*	30	27	9.6*
Female	59	10	3.9	75	1	0.4	32	11	4.3
2-year-old									
Male	46	46	11.8**	37	4	1.2	33	50	12.8**
Female	75	42	12.0**	110	+10	3.1	67	32	9.2**
3-thru-7									
Male	60	40	8.9**	40	7	1.7	42	47	10.5**
Female	215	18	5.0*	303	8	2.3	156	26	7.2**
8-and-older									
Male	19	31	6.7	19	23	5.3	14	54	11.7*
Female	158	22	6.1*	232	3	0.9	122	25	6.9*

All values negative unless indicated by +.
* Significant at 5 per cent t-test
** Significant at 1 per cent t-test.

11 and 10 pound increases followed 11 and 42 pound (7 and 12 per cent) decreases from December to January. Only the 42 pound change in 2-year-olds was significant.

The 3-thru-7 and 8-year-and-older classes each had a significant weight loss of approximately 20 pounds during the first half of the season, while an 8 and 3 pound loss respectively occurred for the latter half of the season. The seasonal weight loss of approximately 25 pounds (7 per cent) for each age group was significant.

Nearly all of the 11 pound seasonal weight loss for the yearlings occurred during the first half of the season.

Hunter-dressed weights are available for 435 females known to have been pregnant and for 89 known not to have been pregnant (Table 2). Although the samples are very small for pregnant yearlings and for non-pregnant animals in the other age groups, it appears that a trend exists. The hunter dressed weights of pregnant animals were greater than for non-pregnant animals in each age class. The animals of the 3-thru-7-year pregnant group averaged 12 per cent heavier than non-pregnant animals of this age class. The 8-year-and-older group was 8 per cent heavier for the gravid animals. These weight differences are significant for each age class. Seasonal mean hunter dressed weights of pregnant females are slightly greater than seasonal mean weights of all females for each age class (Table 2).

Non-pregnant yearlings maintained their hunter dressed weight throughout the season. The non-pregnant 3-thru-7-year group showed a significant increase of 48 pounds in hunter dressed weight from December to January. A larger sample was available for the non-pregnant 8-year-and-older class and although a decline of 34 pounds in hunter dressed weight occurred from December to February, the loss was not significant.

Hunter dressed weights of pregnant animals in the 2-year-old group decreased 34 pounds from December to February, while the 3-thru-7-year group lost 43 pounds and the 8-years-and-older group declined 22 pounds. Each, except the oldest group, was significant at a 1 per cent level.

Weight changes, determined by regressions over the 10-week period, indicated a decline for each female age group as follows: yearlings, 20 pounds; 2-year-olds, 28 pounds, 3-thru-7 years, 43 pounds, and 8-years-and-older, 48 pounds. Within this group were specimens known to have been pregnant and specimens known not to have been. Similar determinations (Table 5) for the 10-week period showed the pregnant 2-year-old group to have lost 51 pounds; 3-thru-7-year group, 60 pounds and the 8-year-and-older group, 46 pounds respectively. Each of these is significant at the 1 per cent level. Non-

TABLE 5. REGRESSIONS FOR HUNTER DRESSED WEIGHTS OF PREGNANT AND NON-PREGNANT ELK DURING A 10-WEEK PERIOD OF THE 1961-62 WINTER.

Classification	Regression	s_b	t-value	df
Pregnant				
2-year-old	y = 356.95 − 5.147X	1.521	−3.383	71**
3-thru-7	y = 390.32 − 6.089X	1.115	−5.458	210**
8-year-and-older	y = 381.52 − 4.566X	1.507	−3.029	145**
Non-pregnant				
Yearling	y = 264.76 − 1.605X	2.047	0.784	38
3-thru-7	y = 239.33 + 11.566X	2.884	4.009	10**
8-year-and-older	y = 357.68 − 5.439X	2.910	−1.869	31

** Significant at 1 per cent.

pregnant yearlings decreased 15 pounds and the 8-year-and-older non-pregnant group lost 54 pounds but each is insignificant. The 115 pound increase revealed for the 3-thru-7-year non-pregnant group may not be an accurate indication due to the small sample.

The data also permit a comparison of weights relative to the sex of fetus carried. Discounting the yearlings which are represented by only three specimens, the seasonal mean hunter dressed weights for each age class indicate that cows with a male fetus are slightly heavier than those with a female fetus. The hunter dressed weights of 2-year-old cows bearing a male fetus were 1.6 per cent heavier than the same aged animals with a female fetus. Respective predominance for the 3-thru-7-year-old group was 2.6 per cent and the 8-year-and-older group 2.8 per cent (Table 6).

GROWTH

Certain animals are characterized by rapid growth during the first 6 months after birth and the growth continues at a lesser rate thru puberty until a peak of development and weight has been reached. Maximum weights may not be attained until 5 or 6 years in white-tailed deer, *Odocoileus virginianus* (Severinghaus and Cheatum, 1956). Males of the black-tailed deer, *Odocoileus hemionus columbianus,* increase in weight throughout life (Brown, 1961) but females reach their maximum weight at about 3 to 4 years of age, and maintain this prime weight until 7 years old before starting to decline

TABLE 6. COMPARISONS OF MEAN HUNTER DRESSED WEIGHTS OF GRAVID ELK AS RELATED TO SEX OF FETUSES.

	2-year class				3-thru-7 class				8-year-and-older class			
	w/male fetus		w/female fetus		w/male fetus		w/female fetus		w/male fetus		w/female fetus	
	No.	Mean weight	No.	Mean weight	No.	Mean weight	No.	Mean weight	No.	Mean weight	No.	Mean weight
December	6	360	2	358	16	376	9	389	6	377	4	338
January	24	316	13	305	57	351	58	342	39	347	40	343
February	11	315	17	321	31	341	40	334	31	351	26	339
Season	41	322	32	317	104	352	107	343	76	351	70	341

TABLE 7. DIFFERENCES IN MEAN HUNTER DRESSED WEIGHTS BETWEEN AGE CLASSES FOR A SAMPLE OF 1,127 SPECIMENS, WINTER 1961-62. SAMPLE SIZES SHOWN IN TABLE 2.

	Males		Females	
	Difference between means:		Difference between means:	
	Pounds	Per cent	Pounds	Per cent
Birth[1] to calf[2]	138	80	122	80
Calf to yearling[3]	99	36	96	39
Yearling to 2-year	89	25	68	22
2-year to 3-7 year	64	15	28	8
3-7 year to 8+ year	7	2	−3	−1

[1] 35 pound males; 30 pound females.
[2] 6 to 8 months old.
[3] 12 to 14 months old.

(Taber and Dasmann, 1958; Brown, 1961). Skunke (1949) has determined that neither the male nor the female moose *Alces a. a.* is full grown before 10 or 11 years of age but the cow's weight increase is small after the third year. Flerov (1952) does not mention a difference between sexes when he reports that growth of red deer *Cervus elaphus* ceases completely by the age of 7 years.

Johnson (1951) found the average birth weight of males (37 pounds) to be slightly heavier than females (32 pounds) in a free living Montana elk population. Murie (1951) stated that a general dominance may not exist between sexes of elk during the first year of life after which the males gradually become heavier as the animals mature. The present collection provides comparisons of mean weights between the six age groups (Table 7). For males, the per cent increase in weight between year classes is much greater in the younger than in the older groups. A leveling off in weight appears to occur between the 3-thru-7-year group and the 8-year-and-older group but the data do not permit a reliable estimate for the age of maximum weight. Females classified in the 3-thru-7-year group appear to have reached a maximum weight. Ages of maximum weight may be more accurately established from subsequent studies.

A comparison of mean weights in each age class shows the males are without exception larger than respective females (Table 2). The difference in weight for each age class is shown in Table 8. The superiority of weights of males was most prominent for December

TABLE 8. DIFFERENCES IN HUNTER DRESSED WEIGHTS OF MALES AS COMPARED TO FEMALES FOR WINTER 1961-62. SAMPLE SIZE IN TABLE 2.

	December		January		February		Season	
	Pounds	Per cent	Pounds	Per cent	Pounds	Per cent	Pounds	Per cent
Calf	+57	26	+19	11	+ 4	2	+21	12
Yearling	+25	9	+28	10	+ 9	4	+25	9
2-year-old	+42	11	+36	10	+24	7	+45	12
3-thru-7	+86	19	+64	16	+65	16	+81	19
8-and-older	+99	21	+90	21	+70	17	+91	21

and generally continued to a lesser extent for January and February. The seasonal differences reveal the three younger male classes were approximately 10 per cent heavier than females, while the males in the two older classes were 20 per cent heavier.

DISCUSSION

Types (live, whole, total, field-dressed, hog-dressed and dressed weight) of elk body weights reported in the literature have varied between different studies and few can be directly compared. Hunter dressed weights are usually the easiest to obtain and provide the best opportunity for comparison between studies. For comparison with this study, previously reported whole or live weights were converted to hunter dressed weights. Hunter dressed weights of males and females 3-years-old-or-older were considered as constituting 68 and 67 per cent of live weights respectively (Quimby and Johnson, 1951). Most studies have used the 3-year-old-or-older category of age and the present data were adjusted to permit comparisons.

The only previously published weights of elk from the Northern Yellowstone herd were weights of live animals obtained during 1946 (Skinner) and the various carcass weights obtained in 1949 by Quimby and Johnson (1951). The latter, collected in late December, indicate hunter dressed weights of males and females to be 8 and 4 per cent heavier than respective sexes for like periods in the present study. A 24 per cent difference appeared between mean weights of sexes during 1949 while a 20 per cent difference was noted for 1961. The weights for January 1946 were 5 per cent greater for males and 4 per cent greater for females than for 1962. The means showed an 18 per cent difference between sexes in 1946.

The lighter weights indicated for elk in this study as compared to the earlier studies possibly reflects the effects of overpopulated ranges during the intervening 13 to 17 years.

Wright (1956) obtained whole weights of mature bulls from the National Bison Range in Montana. He noted, "None of the bulls was fat since they were killed in November or December, but most were in good shape." The calculated hunter dressed weights of the November specimens averaged 525 pounds. Assuming the current regressions represent trends that are continuous and uniform throughout the season, a projection into November indicates 480-pound males which are 45 pounds less than the animals reported by Wright.

Hunter dressed weights obtained over a 5 or 6-month period were provided from the elk herd in Rocky Mountain National Park, Colorado (Guse, 1963). These averaged 505 pounds during three consecutive years which exceeds our 427-pound seasonal average. During

TABLE 9. COMPARISON OF THE REPORTED OR CALCULATED HUNTER DRESSED WEIGHTS OF ELK FROM VARIOUS STUDIES.

Study and herd	Period	Carcass status[1]	Males (3-yr-and-older) No.	Mean	Range	Females (3-yr-and older) No.	Mean	Range
Present	Dec. 11-23, 1961	R	38	451	365 –535	58	362	240 –460
Northern	Jan. 1–Febr. 3, 1962	R	41	415	(325)–510	315	343	(240)–450
Yellowstone	Febr. 5–17, 1962	R	18	404	335 –510	220	337	225 –430
	Season:							
	(Jan. 11, 1961-Febr. 17, 1962)	R	97	427	(325)–535	593	343	(240)–460
Quimby and Johnson, 1951								
No. Yell.	December 1949	R	10	493	448 –555	11	377	334 –445
Skinner, 1946								
No. Yell.	Jan. 30–31, 1946	C	15	437	286 –500	5	358	348 –375
Murie, 1951								
Jackson Hole	Febr. 1941	C	15	422	——	29	342	——
Wright, 1956								
National Bison Range	November 1953	C	18	526	391 –619	—	—	——
Guse, unpubl.	Dec. 1–13, 1944	R	1[2]	433	——	14	364	318 –466
Rocky Mtn.	Nov. 28–Dec. 14, 1949	R	2	396	365 –433	15	366	318 –466
Nat'l. Park	Season (Nov. 1950–April 1951)	R	18	521	407 –640	22	357	300 –460
	Season (Nov. 1951–April 1952)	R	15	500	425 –586	27	353	308 –420
	Season (Nov. 1952–March 1953)	R	4	495	440 –577	11	372	310 –447

[1] R=reported hunter dressed weight; C =calculated hunter dressed weight from whole or live weight.
( ) extreme low weight deleted for next highest.
[2] adults (5 years and older)

the two seasons of 1950-51 and 1951-52, the means of the Colorado specimens revealed a 30 per cent difference between the sexes.

An approximate 200 pound range in weights occurred between extremes for individuals of each sex in the present study, compared with the 100 pound differences noted in 1949. Females in other studies, with at least six observations, have an approximate 150 pound range, as do several male groups, but for a few of the latter the ranges were over 200 pounds. Disregarding the year, kind of winter, range or herd in available reports (Table 9) the female mean weights are rather consistent, having only 40 pounds separating the extremes, whereas the males extend to 130 pounds.

CONCLUSIONS

During a 10-week period of the 1961-62 winter, hunter dressed weights of male elk decreased at a more rapid rate than did those of females, as revealed by regressions. A comparison of mean hunter dressed weights for December, January and February indicated the weight declines were more pronounced during the first half of the season. Hunter dressed weights of pregnant cows were heavier than those of non-pregnant cows in each age class. These same weights for cows carrying a male fetus were slightly heavier than cows with a female fetus. The weights reported in this study are lower than the weights reported in each of several other studies. Weights from the present study suggest elk in poor condition resulting from a prolonged overpopulation that has been subsisting on overused winter ranges. These weights possibly were approaching a minimum for survival reflecting nearly depleted energy reserves under the conditions that existed. This is substantiated by the report (Howe, 1962) that nearly a thousand (476 counted, remaining estimated) animals died during the late winter of 1961-62, apparently from malnutrition and related causes. These initial findings should increase in value as future studies reveal yearly weights that can be related to range changes.

ABSTRACT

A series of carcass weights was obtained for Rocky Mountain elk *Cervus canadensis* during the 1961-62 reduction program of the Northern Yellowstone herd. Hunter dressed weights were obtained between December 11 and February 17 for 271 males and 856 females classified as calves, yearlings, 2-year-olds, 3-thru-7-year-olds or 8-years-or-older. Weights were also cbtained for 414 sets of chest viscera and 324 sets of feet. Weights of females were considered with regard to reproductive status. The weights obtained in this study are

compared with the results of several studies. Possible significance of hunter dressed weights are discussed.

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DISCUSSION

DISCUSSION LEADER ROBINSON: These data are for 1961-62. Do you have later data on the same subject?

MR. GREER: Yes, we do. We are still obtaining animals. The value of this collection soon became apparent to both services, and we did request and receive permission to continue with it to a limited extent. We have been authorized to continue and have done so since the middle of February by collecting 5 cows a week up until the time of calving, which was June 12. After June 12 we resumed our collections again at the rate of about five animals per week in mid-September, and we have been current to the present time.

Since we do have variations in the seasons and the conditions and the populations of animals will reflect various body weights; that is, the whole dressed weights and the visceral weights, and we hope to compile the data soon.

MR. JOHN RINGER (Oregon): In connection with this matter of weight loss, it might be of interest to some of us who might be interested in moving animals or collecting them for one reason or other with immobilization drugs to know that it was necessary in January and February of this year to reduce our concentration by one-half as a result of the poor condition of elk at this time of the year.

My question is relative to perhaps other studies that you might have made. Do you have any information relative to the effectiveness of coverage by spike elk of females?

MR. GREER: No, sir, we do not.

MR. ROBINSON: Ken, you are to be commended for using a management operation to collect such good data.

TECHNICAL SESSION

Tuesday Morning—March 10

Chairman: LARRY R. GALE
Chief, Division of Fish and Game, Missouri Conservation Commission, Jefferson City

Discussion Leader: W. C. GLAZENER
Assistant Director, Welder Wildlife Foundation, Sinton, Texas

FIELD AND FARM RESOURCES

A PRIORITY RATING SYSTEM FOR CANADIAN WETLANDS PRESERVATION

B. J. ROSE AND H. R. MORGAN
National Wildlife Federation, Bismarck, North Dakota

This study, made possible by a Grant from the Max C. Fleischmann Foundation of Nevada, was initiated in 1961.

Its primary objectives are to determine: where duck breeding habitat is threatened by agriculture and how it may be preserved or acquired: (2) how federal, state or provincial and local governments and private organizations might cooperate to preserve such areas in sufficient quantity to assure a harvestable surplus of North American waterfowl.

Our endeavor is now centered on the prairie pothole region of southern Manitoba, Saskatchewan and Alberta. The importance of this region, which extends southward into the Dakotas and Minnesota, has been clearly established by many studies over the past 30 years. During the severe droughts of the middle 1930's and the recent drought of the late 1950's and early 1960's, duck populations were severely reduced. These droughts centered in the prairies, not in the

Far North, hence there is clear warning of the importance of our prairie wetlands. Nature's droughts are severe, but temporary. Man-made droughts, produced through agricultural drainage and filling, are permanent.

Man has been encroaching on the more fertile soils of the prairies for years. Wetlands on the better and richer soils are the first to be drained. There is much evidence that ducks prefer breeding marshes in areas of high soil fertility. Loss of duck production habitat on good agricultural soils pushes birds to wetlands on soils of lesser fertility. In times of high duck populations and/or reduced water areas these displaced birds will find no unoccupied prairie waters. If these drainage stages are continued, production of shootable surpluses on the prairies will be eliminated.

In 1961, we sought a method by which prime duck production areas in prairie Canada could be delineated. Due to the importance of agricultural drainage, it was imperative that drainage susceptibility of the wetlands be given prime consideration.

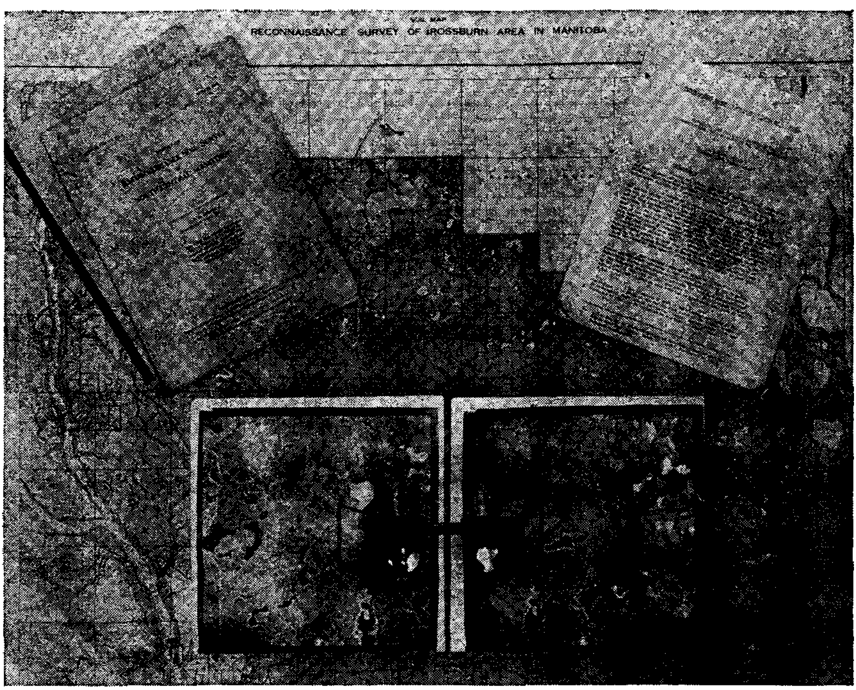

Figure 1. Sources and materials for obtaining tool data. Upper left-soil reports for Tools 1, 2 and 3. Upper right-climatic summary for Tools 4 and 5. Central-aerial photographs and stereoscope for Tools 6 and 7. The background is a soils map used for soil type delineation.

Excellent soil maps and reports are available for the prairie regions of Manitoba, Saskatchewan and Alberta.

Each soil type contains characteristics which give it individuality. The soil type, therefore, was selected as the basic land unit for delineation.

FACTORS FOR RATING SOIL TYPES

Since personal bias is likely to influence judgment in assigning soil types to a priority list, we decided to develop a priority rating system using pre-determined values for the various rating components.

Seven categories or "tools" were finally developed. Point value of each tool is from 1 to 10 points or 1 to 20 points; a total of 100 points being maximum for any soil type. Data for using the seven factors are all easily obtained (see Figure 1). The following is a list and description of these seven rating tools as used in the priority rating system.

Table 1 presents rating data for each tool.

Tool 1. Soil Texture Classification—1 to 10 points. Data for this tool are obtained from provincial soil reports. This tool is important in the ability of various soils to maintain surface water. Heaviest soils receive the most points.

Tool 2. Land Utilization Classification—1 to 20 points. Data obtained from provincial soil reports. This is the same classification as that used by the U.S. Soil Conservation Service. A total of eight classes are listed, with Class 1 being the best agricultural soils with high productivity; from Class 1 the soils are graded down to Class VIII which are impossible to farm and are designated for wildlife and recreational use. The better the soil type for agriculture, the more points it receives under this tool. Since wetlands lying over the richer soils are most likely to be drained first, this is a realistic rating.

Tool 3. Natural Topography and Drainage—2 to 20 points. Data for this tool are obtained from provincial soil reports. This tool considers the possibility of agricultural drainage and the ability of an area to support surface water. The highest point value is assigned to a poorly drained soil type with undulating topography; the most vulnerable to drainage.

Tool 4. Precipitation (annual average)—1 to 10 points. Obtained from climatic summaries published by the Dominion of Canada. The annual average precipitation figures for the nearest reporting stations to each soil type are used here. The higher the amount of precipitation, the more points the area receives.

TABLE 1. RATING TOOLS FOR PRIORITY OF SOIL TYPES

Tool 1 Soil texture classification	Tool 2 Land utilization classification	Tool 3 Natural topography and drainage	Tool 4 Precipitation annual average	Tool 5 Evaporation mean July temperature F°	Tool 6 Number of water areas per square mile	Tool 7 Wetland types
1 = sand and gravel	1 = class VIII	2 = level and well drained	1 = below 5"	2 = 70 or above	1 = 4 or under	4 = type 1 only
2 = mixed-sandy loam to sand	3 = class VII	4 = level and poorly drained	2 = 5– 9.9"	4 = 67.6–69.9	2 = 5– 9	8 = type 5 only
3 = sandy loam	5 = class VI	8 = rolling or undulating, well drained	3 = 10–12.4"	5 = 66.6–67.5	3 = 10–14	10 = types 1 and 3 only
4 = mixed-loam to sandy loam	7 = class V	10 = variable topography and drainage	4 = 12.5–14.9"	6 = 65.6–66.5	4 = 15–19	12 = few scattered communities
5 = loam and silty loam	10 = class IV	12 = steeply rolling, poorly drained	5 = 15–17.4"	7 = 64.6–65.5	5 = 20–24	16 = pothole communities with type 4
6 = mixed-clay loam to loam	13 = class III	16 = rolling, poorly drained	6 = 17.5–19.9"	8 = 63.6–64.5	6 = 25–29	20 = pothole communities with type 5
7 = clay loam and silty clay loam	16 = class II	20 = undulating, poorly drained	7 = 20–22.4"	10 = 63.5 or lower	7 = 30–34	
8 = mixed-clay to clay loam	20 = class I		8 = 22.5–24.9"		8 = 35–39	
9 = clay and silty clay					9 = 40–44	
10 = heavy clay			10 = 25" or more		10 = 45 or more	

Tool 5. Evaporation (indicated by mean July temperature)—2 to 10 points.
Obtained from climatic summaries.
Since evaporation figures are not available for the various soil types, the mean July temperature is used as an indicator. The lower the mean July temperature, the higher the point value.
Tool 6. Number of Water Areas per Square Mile—1 to 10 points.
Obtained from aerial photo interpretation.
Aerial photos of four inches to one mile scale are studied with a stereoscope. These photos are available in provincial mapping offices. Sample size studied is a minimum of five per cent of the total acreage of the soil type. The greater the number of water areas per square mile, the greater the point value.
Tool 7. Wetland Types—4 to 20 points.
Obtained from aerial photo interpretation and also from ground survey work conducted each summer.
The following types of wetlands are used in this tool:

Wetland Type 1—Shallow depressions, usually holding water only in the spring or after heavy rains.

Wetland Type 3—Shallow fresh marshes holding surface water during the spring and early summer. May go dry in late July or August.

Wetland Type 4—Deep fresh marshes normally holding surface water the year-round except during periods of drought.

Wetland Type 5—Open fresh water of variable depth. Often surrounded by marsh vegetation and seldom dry except during periods of extreme drought.

Pothole Community—As used here, is a group of water areas of various types within a mile radius.

The most important wetland areas are pothole communities with a Type 5 water area. The satellite ponds provide nesting and brood rearing habitat while the Type 5 water area provides a permanent water supply if the more temporary waters dry up. These communities, potentially, are the best producers and receive the full 20 points.

These seven tools represent a possible 100 points on the rating system. Tools 1 through 3 consider the soils, land use and topography for a maximum of 50 points, and Tools 4 through 7 consider climatic influence and water areas for the remaining maximum 50 points.

APPLICATION OF RATING SYSTEM IN SOUTHWEST MANITOBA

The southwest corner of Manitoba was the first area to be treated, using the described method. This is the region designated as Stratum

"A" by the U. S. Fish and Wildlife Service and Canadian Wildlife Service.

A total of 41 soil types or topographical phases were rated. Topographical phases are delineated on the larger soil types which lend themselves to this further breakdown. The following point values were used to establish the priority:

Priority I	80-100
Priority II	70-79
Priority III	50-69
Priority IV	25-49
Unimportant	Below 25

After all soils of Stratum "A" had been rated, the following acreages and priorities were determined:

Priority I	1,910,722 acres
Priority II	1,875,095 acres
Priority III	2,257,712 acres
Priority IV	1,177,623 acres
Unimportant	829,526 acres
Total	8,050,678 acres

Table 2 presents the various soil types with the rating tools applied and total point value accumulated by each. Locations of Priority I and II soil types are shown on the map (Figure 2).

DISCUSSION

Small water areas located upon soil types most desirable for agricultural crop production offer high duck production potential. These wetlands, therefore, are the most vulnerable to drainage and filling which is continuing at an alarming rate. If ducks are to be perpetuated in harvestable numbers, suitable production habitat must be preserved.

Application of the method discussed to all soils of prairie Canada develops a clear picture of areas requiring first consideration under any production habitat preservation effort.

Such effort must be practical to succeed.

Preservation methods to be considered include purchase, lease, easement, incentive payment and tax abatement, or a combination thereof.

Purchase is necessary if development is a factor. Acquisition of wetlands in the endangered Priority I soil types, though costing more, will be of greater future benefit than the purchase of a greater area in Priority III soil types, not now being threatened. Since the public considers total acreage under government ownership, this might result in less public antagonism. The tax problem inherent to

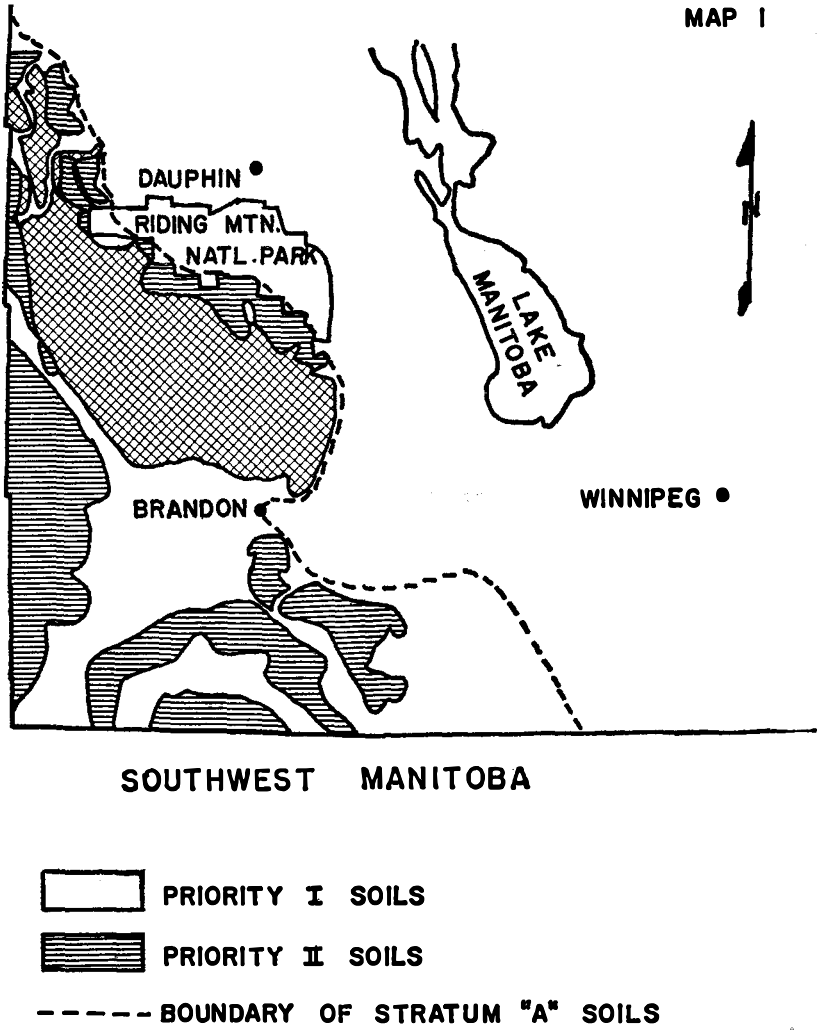

Figure 2. Map of southwestern Manitoba. Showing locations of Priority I and II soils.

purchase, in some instances, may be comparable to the cost of leasing. It is reasonable to expect payment in lieu of taxes to increase as land values rise.

Lease or easement, although not requiring the initial outlay of funds, precludes development, is seldom permanent, and establishes a cloud on the owner's title.

Incentive payments offered to landowners who agree to maintain

TABLE 2. PRIORITY RATING AND LISTING OF SOIL TYPES IN STRATUM A OF MANITOBA

Soil type	Acreage	Tool 1	Tool 2	Tool 3	Tool 4	Tool 5	Tool 6	Tool 7	Total points
Newdale (undulating)	1,044,135	7	16	20	6	6	10	20	85
Erickson	401,379	7	16	20	5	7	7	20	82
Newdale (rolling)	82,176	7	16	16	6	7	9	20	81
Newdale (smooth)	383,032	7	16	20	6	5	10	16	80
	1,910,722—acreage in priority I								
Waskada (undulating)	287,890	7	16	20	6	5	7	16	77
Oxbow	753,467	7	13	20	6	5	10	16	77
Newdale (modified)	149,631	6	13	20	6	7	8	16	76
Turtle Mountains	146,437	6	13	16	6	6	9	20	76
Waitville	255,598	7	13	16	5	7	8	20	76
Hilton	160,768	6	13	20	6	5	5	20	75
Tiger Hills	121,304	7	10	20	6	5	6	20	74
	1,875,095—acreage in priority II								
Harding	64,150	9	16	10	6	5	5	16	67
Altamont	79,353	8	16	10	7	4	3	16	64
Waskada (rolling)	155,961	7	16	8	6	5	6	16	64
Oliver	11,759	9	13	4	6	5	10	16	63
Heaslip	221,948	5	16	10	6	5	4	16	62
Snowflake	153,867	7	16	10	7	4	2	16	62
Pipestone	34,587	9	16	4	6	5	4	16	60
Beresford	57,600	7	16	10	6	5	4	10	58
Glenboro	50,364	4	16	8	6	5	2	16	57
Carroll	458,998	7	16	10	6	5	2	10	56
Darlingford	73,914	7	16	8	7	4	2	10	54
Pembina	281,738	7	13	10	7	4	1	12	54
Greenway	13,999	5	7	10	6	5	5	16	54
Waskada (modified)	132,556	6	13	8	6	5	6	10	54
Lenore	35,662	7	13	10	6	5	3	8	52
Manitou	107,191	7	16	8	7	4	1	8	51
Hecla	43,836	8	13	10	6	5	1	8	51
Waskada (smooth)	261,391	7	16	4	6	5	3	10	51
Indian Springs	18,838	6	13	10	7	4	2	8	50
	2,257,712—acreage in priority III								
Cartwright-Bede Complex	25,118	3	10	10	6	5	3	10	47
Bede	99,168	1	7	10	6	5	2	16	47
Souris	635,235	3	13	4	6	5	4	10	45
Whitewater	87,818	6	7	8	6	5	3	8	43
Miniota	194,473	3	10	2	6	6	1	10	38
Marringhurst	135,811	3	7	2	6	6	1	4	29
	1,177,623—acreage in priority IV								
Others									
Unimportant									
Arrow Hills	15,000								
Chesterfield	15,572								
Coulter	15,532								
Neelin	7,079								
Assiniboine	186,264								
Dune Sands	44,251								
Eroded slopes and channels	468,751								
Oxbow channels	28,317								
Benchlands	48,760								
	829,526—acreage of unimportant soils								

wet areas do not insure permanent preservation. This is also true of tax abatement provisions which involve the government.

Smith and Jordahl (1959) proposed a variable lease payment based on land quality in Wisconsin. The wetlands rating system we are presenting could be easily adapted to a variable lease program.

For example, payments could be based on the priority rating or total point value received by the soil type.

The Wisconsin approach might also be applied to an incentive or tax abatement type program.

In addition to the Manitoba area reported on in this paper, we have now completed the rating of over 45 million acres in Saskatchewan. An additional 20 million in Saskatchewan, and 40 million acres of Alberta are presently being rated.

The method presented clearly delineates those areas which should receive immediate attention. Without meaning to be trite, these must be our "battlelines" to defend now, or lose forever.

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DISCUSSION

DISCUSSION LEADER GLAZENER: Thank you, Mr. Rose. We have heard what seems to be an orderly and logical approach to what frequently is a difficult problem.

For some people who have confronted the problem of selecting, negotiating and acquiring land for wildlife purposes, I suspect that there are likewise those present who have had no such guidelines to follow and, as a result, there should be some questions or comments pertaining to this. We would be glad to entertain them.

DR. EUGENE BOSSENMAEIER (Manitoba, Canada): I would like first of all to congratulate Mr. Rose and Mr. Morgan for this study and to compliment the National Wildlife Federation and the Fleischmann Foundation for seeing fit to sponsor it.

I can say, speaking in behalf of Manitoba, that we are very pleased to have these men in our province and also that we look forward with a great deal of enthusiasm to the results of this study.

I can add further that we are very pleased with the results.

The field of land classification has become very popular in Canada in only the last two years. I don't think that either Mr. Rose or Mr. Morgan anticipated this when they came to Canada, but it is a coincidence that with their arrival the Agricultural Rehabilitation and Development Program came into force across Canada.

One of the first things that this program wanted to do was to classify land for its capability of producing various products. Immediately, wildlife was placed on that same level with wheat, beaver, recreation and forestry, and we thought this was a very fortunate chain of circumstances.

Now then, we are being asked to classify land for wildlife uses in Manitoba and these other users are also being asked to classify these lands, the group decided there had to be a common denominator. Unfortunately, this common denominator is economics and the person that receives the most attention now in Manitoba when we sit down as a group is the economist, because he apparently is the only one who can make sense out of all of these various sources of data.

The study that has just been reported on is a qualitative study. We know now where the better wetlands lie in Manitoba. We know their strength and location. However, when we sit down with the group in Manitoba I am still asked to come up with figures for the waterfowl production capability of these potholes. Secondly, I am asked to come up with figure as to what a duck is worth.

As I said before, I think this is unfortunate, and I think we realize all the ramifications of this problem. However, it is a problem that we are faced with today.

In the minds of many people, we need this waterfowl production capability, and we need the value of a duck before we can justify saving the wetlands.

MR. R. K. DAVIS (Resources for the Future): It seems fair to say that you have ranked the land types according to wildlife benefits. This seems to me to neglect the other side of the equation, the cost of acquiring these lands.

My question is—are there significant differences and consistent differences in the cost among the different priority groups?

MR. ROSE: If I may, I would like to direct this question to Mr. Morgan, who is also the project coordinator.

MR. MORGAN: Mr. Chairman, Mr. Davis and ladies and gentlemen: in answer to your question, it was impossible, of course, in the short time allotted this discussion, to go into all the facets of the program and the many things we hope to develop and eventually publish a report on.

One of the important parts of the survey, one of the important objectives is to try and determine what the attitude of private landowners is primarily in the three provinces that we are discussing—as to what their attitude might be toward a preservation program. Also, another very important part is to try and determine what method of program for preservation might be used—whether it be outright acquisition in fee title, whether it be longer term or leases in perpetuity or just what it might be. We have not gotten into those phases of the program as yet, as much as we would like to, and as much as we intend to prior to the time that we closed the program. However, we hope to be able to come out with some very definite figures and guidelines.

MR. GLAZENER: Thank you, Mr. Morgan. Are there any other questions?

I had intended to ask whether or not this system had been applied in any action program up to this time. I suspect that is a premature question.

MR. MORGAN: It has been applied, but to what extent I am not able to answer although there have been definite indications on the part of the provincial game people in the few provinces in which we are operating that it will be applied. I think from the remarks of the previous speaker that you will gain an indication of the interest shown in Manitoba. This was the first area in which we came anywhere near completing the survey.

MR. SETH GORDON (California): Having attended these conferences and participated in them at since about 1920 or 1929 and having missed only one during that period, I am proud to say that in my judgment this is one of the most constructive papers we have had at these conferences over the years. It sets up a yardstick, a pattern, which all of us ought to be able to apply and I congratulate the authors upon a very well done job.

A STUDY OF THE INTRODUCTION, RELEASE, AND SURVIVAL OF CERTAIN EUROPEAN AND ASIATIC GAME BIRDS[1]

A. S. JACKSON[2, 3]
Parks and Wildlife Department, Canadian, Texas

Texas has been the scene of many undocumented introductions of exotics. The Texas Game, Fish and Oyster Commission first undertook propagation of pheasants in 1919 and began to license game breeders in 1933 (Texas Game, Fish and Oyster Commission, 1935). Countless operators of backyard game farms have since made hopeful releases of the birds they reared. The foreign game birds introduced into Texas by the state game agency range from wild guinea-fowl (*Numida meleagris*) secured from Cuba and liberated in south Texas to Hungarian patridges (*Perdix perdix*) secured from Canada and liberated in the Panhandle and Rolling Plains (Texas Game, Fish and Oyster Commission, 1945). During 1959 a total of 23,873 coturnix quail (*Coturnix coturnix*) was liberated in 29 Texas counties (Texas Game and Fish Commission, 1960). The same year, French red-legged partridges (*Alectoris rufa*) and gray francolins (*Francolinus pondicerianus*) were reared at the State Quail Hatchery from stock imported under the Foreign Game Introduction Program. Several liberations of both species were made. At least two liberations of French red-legged partridges were wiped out by predation. Results of other liberations are, at best, inconclusive at this date.

During 1958-59, a total of 675 chukars (*Alectoris graeca*)from California and Nevada sources was liberated on the Black Gap Wildlife Management Area in Brewster County (Parker, 1964). Some of these birds still exist on the area.

All these attempts at establishment of foreign species were alike in two respects: superficial similarities between native habitats and liberation areas were used as guides to trial introductions, and no organized investigations were carried out as follow-ups.

Bump (1951) has presented a policy for the Foreign Game Introduction Program. In brief, adaptable species are sought for habitats which have been changed beyond practical rehabilitation for native species, and for habitats which have never supported native game in huntable numbers. The ecologic appraisal and comparison of the native habitat with that to be stocked is implicit.

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[1]A contribution from Federal Aid in Wildlife Restoration Texas Project W-70-R.
[2]The author acknowledges the assistance of Richard DeArment and A. W. Jackson, Wildlife Biologists, Pittman-Robertson Wildlife Restoration Program.
[3]In the absence of the author this paper was read by Mr. E. A. Walker.

Following preliminary negotiations, Gardiner Bump[4] reconnoitered the Palo Duro Canyon and the eastern counties of the Panhandle during August 1954. Certain aspects of the habitats led him to recommend that introductions be made of Spanish red-legged partridges (*Alectoris rufa hispanica*) and see see partridges (*Ammoperdix griseigularis*) in locations of his selection.

Subsequently, a cooperative agreement was reached among the Texas Game and Fish Commission, the U. S. Department of the Interior, Fish and Wildlife Service, and the Wildlife Management Institute, whereby the latter two agencies would secure the foreign game birds. A three-year Federal Aid project was initiated January 1, 1955, providing for investigations by qualified technicians with the following objectives:

1) To determine proper liberation procedures, conditions, and management for the species selected.
2) To determine the reaction of the introduced species to the conditions within the region into which they were liberated.
3) To determine the reaction of native species to the introduced species.

During February 1957, the third segment of the project was amended to permit a study of trial introductions of hatchery-reared coturnix quail to be made in central and west Texas counties.

Over the three-year project term (1955-57), 376 Spanish red-legged partridges were received from Spain, and after varying periods of confinement at liberation sites, 332 were released.

Over a two-year period (1956-57) a total of 259 see see partridges were recieved from west Pakistan and 241 were liberated into the Palo Duro Canyon in Armstrong County.

During the last year of the study, 999 coturnix quail were received in six separate shipments from the State Quail Hatchery. These were released in about equal numbers on the Heep Ranch, 15 miles south of Austin, and near Esperanza, 60 miles east of El Paso. It should be noted here that the selection of locations was purely experimental.

All the above introductions failed. The purpose of this paper is to contribute to the limited amount of information available concerning these foreign game birds in areas of their introduction.

SPANISH RED-LEGGED PARTRIDGES

Liberation areas. When Gardiner Bump made his inspection trip, he suggested as tentative liberation areas for Spanish red-legged par-

[4]Biologist in Charge of Foreign Game Introductions, Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Servce.

tridges the following habitat types in order of preference: the oak-brush (shinoak) and cultivated fields area north of the Salt Fork of the Brazos River in Stonewall County, the shinoak-sands northeast of the Palo Duro Canyon, and the sagebrush-pasture and wheatlands interspersion in Hemphill County.

By fall, drought had narrowed the choice of such a location to one on the south fork of the Pease River in Cottle County, a site conforming closely to the one that had been chosen earlier.

Preparations were also made for liberating red-legged partridges in the north Panhandle early in 1956, providing enough birds could be secured for liberations in two locations. Again, reconnaissance of several counties was necessary before a ranch was found in Lipscomb County which included within its boundaries fields of growing wheat, shocked grain sorghums, and sagebrush pastures with running water.

The liberation sites selected were more or less typical of about 12,000 square miles of Panhandle Rolling Plains when under favorable rainfall conditions. In this region, populations of scaled quail and bobwhites fluctuate widely with changing rainfall and grazing effects. To establish itself in vacant ranges of the kind occurring in the Rolling Plains, an exotic species should be able to subsist upon green forage available in the winter months, and possess enough independence of cover to forage widely in open fields.

Procurement and management. The Spanish red-legged partridges were wild-trapped in southern Spain and the northern province of Salamanaca. A mandatory period of 60 days in captivity was required for inoculations with killed Newcastle vaccine and observations before shipment. From Madrid, the partridges were air-expressed to New York for another 15 days of quarantine. They were then air-expressed to Dallas and transferred to a light truck for delivery to liberation areas. All shipments were at liberation sites within 24 to 36 hours after leaving New York.

The individual shipments, numbers of partridges, losses, and dates received are shown in Table 1.

The Lipscomb County area was allotted approximately one-half of the partridges received in 1956 and 1957.

TABLE 1. INTRODUCTIONS OF SPANISH RED-LEGGED PARTRIDGES IN TEXAS, 1955-57

Dates received	No. shipped (New York)	Losses in transit	No. received liberation area
Feb. 3, 1955	76	0	76
Mar. 10, 1955	104	17	87
Feb. 16, 1956	123	0	123
Feb. 5, 1957	95	5	90
Totals	398	22	376

Partridges in the first shipment were in excellent condition. In contrast, 17 were dead on arrival of the second lot. Three birds were barely alive; however, these recovered while three others died within 48 hours. Numerous loose feathers in the crates indicated some sort of rough handling en route from New York.

The 1956 lot of partridges arrived in good condition with exception of a single bird which died the day following receipt.

The 1957 lot of Spanish redlegs arrived in very sorry condition. Five birds were dead in the crates, five others died within 24 hours, and eight were in hopeless condition. All were emaciated and feather-light, evidencing improper care while in transit or recent recovery from some infection.

A "gentle release" method was employed by first confining the partridges for a period of four days to two weeks in two pens separated by a distance of 300 yards. This afforded the birds opportunity for orientation and improvement of their physical condition before liberation.

Conditioning pens were constructed of 1-inch mesh net wire, 26 feet in length, 6 feet in width, and 45 inches in height. Edges were buried 27 inches below ground level to discourage predators.

Disturbance of the partridges while confined was kept at a minimum. The hazard of injury by collision with wire sides was avoided by feeding and watering after nightfall behind a bright spotlight.

Food needs of Spanish redlegs were easily met; they ate locally grown rye and milo maize, a variety of commercial poultry feeds, and the green blades of growing wheat, rye, and annual brome grasses. As drouth conditions worsened, local greenery became scarce and was replaced by alfalfa hay.

Experience with the first lot of partridges made it apparent that penned birds were great attraction to predators. A single skunk (*Mephitis mephitis*) and 19 great horned owls (*Bubo virginianus*) were trapped at the four holding pens on the two liberation sites during the last two years of introductions. Despite the safeguards used, predators caused the deaths of 17 penned partridges.

Serious mortality occurred in only one shipment of 90 partridges received February 5, 1957. Twenty-five of these died from an apparent weakened condition.

Liberations from the pens were made by means of a pull-cord operated from a distant blind. A screen-door spring had been rigged to close the gate, thus permitting control of the number of partridges to be retained as decoys.

Reaction to conditions into which liberated. Dispersal began at once when the first lot of partridges was liberated on the Cottle County area. Within two weeks, only five or six partridges were to be found in the vicinity of the release site. It was determined that movement had been radial and accompanied by severe predation, apparently by horned owls and accipiter hawks.

The 84 partridges liberated March 30 in the same area did not immediately scatter. For about three weeks it appeared that most of the birds had established home ranges and might nest in the vicinity. All were associating in pairs and small groups. No predation was evident. Then, in a period of dust storms and hot winds, these birds, too, began a wide dispersal.

Surveys during the following months resulted in the mapping of three areas where groups of partridges were utilizing fields of oats, rye, and vetch. The farthset of these was one and one-half mile from the release point.

The second-year liberation of Spanish redlegs in Cottle County was made April 19, at which time all the birds appeared to be paired. Again three areas were found where the greatest number had established home ranges following release. These were within a radius of one and one-quarter mile of the release point. A single partridge was found 6 miles from the release point.

The first liberation, comprising 56 Spanish redlegs, was made in Lipscomb County during April 1956. These quickly scattered and a week later only about one-third of the number could be accounted for.

A summary of known populations at the end of each year of introductions follows:

1955: Eleven partridges, or approximately 7 per cent, of the 157 released on the Cottle County area were known survivors as late as November. Predation was known to have accounted for 26. There were no known broods.

1956: The December population of the Cottle County area was counted as 22 partridges. This was approximately 34 per cent of the spring number at its highest count of 64 birds (59 second-year release plus 5 survivors of the first-year release). Young redlegs had been reported by ranch residents on four occasions; however, these reports probably represented only two broods. Project personnel found tracks, droppings, and dusting sites of adults and young. The ranch owner found and watched for some time a parent and newly hatched brood of 10 young on June 27. The brood was located again the next day. It was not found again, although signs were noted at the location a week later.

Fourteen of the 56 partridges liberated on the Lipscomb County area remained at the end of the year. No broods had been found, and the birds had regrouped and remained in one flock since July 1.

1957: Twelve redlegs remained on the Cottle County area at the time when 33 additional partridges were released in February. Once, during the summer, an estimated 15 or more half-grown young were flushed from a mesquite thicket one-half mile from the release point. These were never seen again. At the time of the fall count in October, 22 redlegs were found.

A March blizzard with 75 mile-per-hour gales and deep drifting snow followed the February liberation of redlegs in Lipscomb County. After the snow melted, only 4 partridges of the known population of 41 (27 newly released and 14 "wild") could be found.

Habitat preferences. The Spanish red-legged partridge is a browser of green vegetation, precluding much competition between the redleg and native quail. The most striking behavior of the redlegs was their morning and afternoon flights out into open fields.

The Spanish red-legged partridge is at home in more open range than is liked by quail. Feeding partridges do not move in compact coveys but advance across a field or pasture in open formation, sometimes keeping considerable distances between members of the group. Contact is maintained by a series of low clucking calls which enables a simultaneous flush if the birds are disturbed.

Spanish redlegs preferred lotewood condalia (*Condalia obtusifolia*) over all other cover for loafing and dusting in Cottle County. Where this shrub was not available, as in Lipscomb County, the partridges used wind-drifted Russian thistle (*Salsola pestifer*), wrecked farm implements, and fallen trees for cover.

Roosts were found in weedy dry gulleys, on sides of field terraces, and at base of shallow "pour-offs" where erosion was undercutting grass turf. The birds roosted in a loose group with intervals of several feet sometimes separating individuals.

Feeding and watering habits. The habitual use of lotewood for loafing cover resulted in accumulations of droppings which were easily distinguishable from those of quail. A fall and winter field analysis of these indicated green vegetable fiber made up 90 to 95 per cent of the droppings of the redlegs. Seeds and insects made up nearly as much of the scaled quails' droppings, and those were common to both species.

The caecum of a Spanish redleg is very large for a bird of its size, approximately three times as large as that of a bobwhite quail. It may be that this represents an adaptation for consumption of plant material in the green stage. It may also make the bird more independent of drinking water by allowing for a greater intake of succulent vegegation. The importance of free water to the Spanish redleg was not determined; however, frequent observations indicated little utilization.

Influence of weather. The first-year introduction of Spanish redlegs was subjected to many extremes of weather—sandstorms, a late freeze which killed vegetation, and long periods of sustained high temperatures during July and August.

The partridges paired off about the middle of April and rejoined to form groups about the second week of July. The regrouping concurred with a period of extreme drouth effects. The rainfall during July and August was approximately 2 inches less than the 4.16-inch normal for the period. July had 27 days with temperatures above 90°F., and 5 days with temperatures above 100°F. August had 30 days of temperatures above 90°F., of which 13 days went above 100°F.

The second year was even dryer in Cottle County with 7.62 inches of rainfall recorded, less than a third of the 24.11-inch annual normal. Lipscomb County had even less.

In contrast to the first two years, the last year was one of violent floods, wind and hail storms. The final release of redlegs in Lipscomb County was concurrent with a severe March blizzard that took a heavy toll which has been described earlier.

Reaction of native species to introduced Spanish red-legged partridges. A group of 10 red-legged partridges and a covey each of bobwhite and scaled quail shared for a time a common home range in Cottle County. Bobwhites used the heavier pockets of brush and were seldom in contact with the redlegs. Redlegs and scaled quail were more mobile, and came in contact more frequently. No instances of incompatibility were observed. On one occasion, Spanish redlegs, scaled quail and mourning doves were observed associating amicably together in a stock corral.

SEE SEE PARTRIDGES

Liberation area. See sees were released into the Palo Duro Canyon in Armstrong County. The canyon terrain is a rough and broken "badlands" as a result of erosion which has cut through the plains soils, their caliche base, and successive underlying strata. A greater variety of vegetation occurs in the canyon than is found on the surrounding plains. Water is present in springs and streams.

The area of introduction lies in the 20-inch rainfall belt. Summer temperatures are excessive because of the reflecting quality of canyon walls and protection from winds. For the same reasons, winter conditions in the canyon are less severe than they are on top.

Procurement and management. See sees were shipped by air from New York to Amarillo. Forty-six see sees were received May 28, 1956 and released after 12 days of confinement at the release site. Shipments comprising 120 and 96 see sees were received March 29 and April 4, 1957, respectively. Three birds died in the three shipments. The last two lots were released on April 3 and 7. Confinement was held to a minimum because of the late season and the possibility that the birds' reproductive season might be upon them. Indeed, on release, it was apparent that many of the birds were paired. Losses in pens totaled 18 see sees, leaving 241 liberated during the two seasons.

Reactions of see sees to new habitat and relationships with native game birds. This phase of the study resulted in negative findings. An explosive scattering followed quickly after releases of the see sees, and none was known to establish a home range. Only one see see was observed after liberation. The rapid dispersal, and scarcity of game birds in the canyon area precluded any study of the reactions of native game birds to these partridges.

COTURNIX QUAIL

Liberation areas. Coturnix were released on the Heep Ranch, 15 miles south of Austin, and near Esperanza, 60 miles east of El Paso. The Heep Ranch is part of an extensive area of semi-black soils used for farming and ranching. The surface is flat to rolling. Pasture land is interspersed with fields of corn, oats, and grain sorghums. Water is well distributed.

The Esperanza area is situated in the bottom land of the Rio Grande. Irrigated farming is the principal land use. Cotton, alfalfa,, and small grains are grown. At the time of coturnix releases, many fields were fallow because of lack of irrigation water. These provided good game cover and food. Dense thickets of salt cedar (*Tamarix* sp.) and other brush species occur along field borders and irrigation ditches.

Procurement and management. Transportation from the State Quail Hatchery presented no problems, nor were problems encountered in feeding or management of coturnix quail while in conditioning pens at release sites. The latter phase represented only continuation of their hatchery existence.

A summary of releases of coturnix quail on the two areas is given in Table 2.

TABLE 2. COTURNIX INTRODUCTIONS, HEEP RANCH AND ESPERANZA AREA, 1957

Area	No. received	Date	Loss	No. released	Date
Heep Ranch	299	Apr. 26	0	299	May 15
Heep Ranch	200	Jul. 11	0	200	Jul. 11
Esperanza	300	May 1	14	100	May 8
				90	May 15
				98	May 21
Esperanza	200	Jun. 11	0	200	Jun. 11
Totals	999		14	987	

Liberation procedures. Three methods of making releases were employed in attempts to find a technique which would result in the least amount of immediate scatter from the areas: 1) lots of approximately 100 coturnix were released weekly until all of a shipment had been freed; 2) coturnix were released after 20 days by opening gates before daylight and allowing birds to walk out at dawn; 3) the remaining shipments were released directly from crates into the fields after observations of results of above methods led to opinion that the techniques were valueless in the case of pen-reared birds.

Reactions of coturnix to conditions into which liberated. On both areas the majority of coturnix were scattered within a short time. A small number used the pens as headquarters for several days, and adults particularly made frantic efforts to reenter the pen. They were still trying to reenter the pen until 51 adults were caught by hand and carried to heavy field cover one-quarter mile from the pen.

Scattered small groups of coturnix were seen on the Heep Ranch during the summer months. A single bird from the first liberation was seen approximately 2 miles from the release point on June 14. This was the greatest distance any coturnix was seen from the place where released, and there were no reports of observations by owners of adjacent lands.

At the end of 1957, it was apparent that coturnix quail had disappeared from both areas of introduction.

Reaction of native species to introduced coturnix quail. Opportunity did not develop to study competition for food and cover, or friction between native game birds and coturnix quail.

SUMMARY AND CONCLUSIONS

Nothing in the brief history of see see and coturnix introductions was encouraging; liberations of both species disappeared quickly, giving no opportunity to observe them acting "naturally" on home ranges, however impermanent.

On the other hand, the Spanish red-legged partridge, despite ultimate failure to establish itself, seemed much at home in the open field-pasture margins where numerous groups lived for a time in niches of habitat as distinctly defined as those of native quail.

From what was seen of them, it did not appear that either see see partridges or coturnix quail possessed game qualities which would appeal to many hunters. Conversely, the Spanish red-legged partridge has to a high degree the indefinable style which distinguishes the world's historic and best loved upland game birds.

To assign climatic extremes as a cause for failure of the Spanish redlegs would be conjectural, but it seems safe to say that weather and predation were factors heavily involved. Bump (1958) states that Spanish redlegs are most abundant where there is little snow throughout the winter, and that "throughout the range . . . winter temperatures seldom fall much below freezing during the day." Application of these limitations alone would have ruled out suitability of the northern one-half of the Texas Panhandle for Spanish redlegs, yet the Cottle County introduction failed as surely in the absence of deep snows or blizzards.

Weatherwise, the introductions were badly timed through nobody's fault. Drought simply hung on beyond expectation. The result was that the partridges were released into a deteriorating habitat at a time when native birds were undergoing sharp declines. Prey species were all declining, and a heavy predator population was facing food shortage. Impressive evidence of the latter was the trapping of 16 great horned owls at the prairie-sited conditioning pens in Lipscomb County.

The native quail did little renesting during the torrid summers following introductions of Spanish redlegs. In the case of the relatively few partridges, conditions adverse to renesting could have proved disastrous.

During the past three years, scaled quail have almost completely disappeared from a number of Rolling Plains counties, including Cottle, where in 1958, eruptive populations occurred. The reasons for this decline are obscure, but it is not difficult to imagine the outcome, if during this time, 300 scaled quail had been trapped from other Texas ranges and liberated in Cottle County. The stocking would have failed.

In summation, the failure of the Spanish redlegs to establish themselves in this case is not believed to justify a conclusion as to their adaptability to the southern part of the Texas Rolling Plains.

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DISCUSSION

VICE CHAIRMAN GLAZENER: Thank you, Mr. Walker.

The past sessions of this conference have brought to us reports, usually the optimistic reports preceding release or early in the stages of a restocking or transplanting program involving exotics. It seems particularly appropriate at this time to have a little more complete story instead of sweeping the problems under the rug and forgetting about them.

Mr. Walker is under some handicap with reference to answering questions, although he was Pittman-Robertson Coordinator at the time the releases were made.

Are there any questions or comments?

MR. DOUGLAS HEY (South Africa): I listened with a great deal of interest to this paper and the thing that interested me most is your thinking in this matter is so radically different from ours.

We have had experiences with the importation of what we call exotic birds or animals and those that did survive, our predators did a very good job on. Therefore, our experience has been so unfortunate that we are very adverse to importation in relation to any foreigner.

The first thing that we try to do, if there is a disappearance of our own particular forms, is that we, through our farming practices, attempt to replenish them by improving the habitat. However, if this cannot be done, we then find out first of all whether the ecological conditions are suitable for an exotic form and then decide whether it will create a problem.

I don't think we are entirely opposed to exotic animals because our fisheries have been based on exotic forms. However, we are careful when it comes to birds and animals.

I wonder if you have any forms in Texas that could have done the job you tried to do with the exotics?

MR. WALKER: In the part of the state where the exotic bird introduction program is being attempted, we do have varying degrees and varying population levels of mated game birds. It so happens that in the Texas Panhandle we did experience tremendous fluctuations in native game bird populations. We were searching for a bird that could do with much less cover than the bobwhite and one which must subsist very largely in the wintter on green vegetation. There is not at this time a huntable population of bobwhite in these areas. We also have had no indication that there is a possibility of developing habitat with the type of agriculture which is now prevalent.

VICE CHAIRMAN GLAZENER: I could have answered that in part this way—that in my association with Texas Game and Fish Commission earlier, I can assure you that we resisted for years the idea of introducing exotics so far as official action of the commission was concerned. A lot of it took place without our knowledge, without our consent and in the absence of any control that we wanted to put on to discourage it.

MATEDNESS IN THE MOURNING DOVE AND ITS EFFECT ON THE NATIONWIDE DOVE-CALL CENSUS

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The purpose of this article is to discuss recent mourning dove research which has revealed that unmated males coo at a higher rate than do mated males. Also, we will consider approaches to evaluating the potential influence that differing cooing rates of mated and unmated males may have on the validity of the results of the annual nationwide coo-call census. In order to do this, I will consider experimental models of mourning dove breeding populations with varying ratios of matedness, and attempt to define the limits of the problem.

THE MOURNING DOVE CENSUS METHOD

The annual survey of the mourning dove breeding population involves counting the number of doves heard cooing (the perch coo) at each of 20 stops, 1 mile apart, along established routes. The listening period at each stop is 3 minutes and the census period begins one-half hour before the time of local sunrise, and continues to one and one-half hours after sunrise. The survey is accomplished during the period May 20 to June 10 each year. The average number of doves heard cooing per route was selected as the population index because it demonstrated less variation than total coos or numbers of doves seen (Foote *et al.*, 1952).

The dove-call census was first adopted to measure breeding populations in the United States in 1953. Since that time the route coverage has increased to include Canada. In 1963, approximately 800 routes were run.

Although much research was conducted in order to establish the coo-call census technique, it has only been recently that intensive research has more fully revealed the basic biology of cooing in the mourning dove. One study, conducted by the Missouri Cooperative Wildlife Research Unit, using penned doves, demonstrated that unmated males cooed at a much higher rate than did mated males (Frankel and Baskett, 1961). This finding was verified by a field study conducted by Gary Jackson (1963) at Missouri, and has been further supported by two studies still under way in Arizona (Harold Irby—Arizona Cooperative Wildlife Research Unit and Lytle Blankenship of the Bureau of Sport Fisheries and Wildlife). In all studies, the unmated males cooed at a much higher rate than did the mated males. We will not consider here the relatively minor differences in cooing rates among mated males associated with the various stages of the nesting cycle.

The finding that major differences in cooing rates exist between mated and unmated males has introduced a need for understanding how this may bias the results of the dove-coo-call census. A serious bias may result if the ratio of mated to unmated males in the breeding population changes materially from year to year. At the present time there is no information on the ratio of matedness in the male population. Furthermore, there are no methods of directly determining this ratio. However, if the reasonable assumption is made that in a population with excess males all females will be mated, it is possible to examine the magnitude of the problem.

METHODS

Hypothetical Models:

The use of population models is helpful in understanding the implications of matedness ratios on the coo-call census results. Some assumptions are required for the use of the models. They are as follows:

1. All adult females in the population are mated.
2. All mated males in the population have the same probability of cooing in a 3-minute period.
3. All unmated males have the same probability of cooing in a 3-minute period.

Definitions:

The following symbols are used in the hypothetical models:

n = the number of doves heard calling

N_u = the number of unmated males within the hearing radius of the observer (whether they call or not).

N_m = the number of mated males within the hearing radius of the observer (whether they call or not).

N = the total males within a hearing radius of the observer (whether they call or not) ($N = N_u + N_m$).

P_u = probability that in a 3-minute interval an unmated male will call (equals .93).[1]

P_m = probability that in a 3-minute interval a mated male will call (equals .23).[1]

K = the number of mated males per unmated male in the population (the matedness ratio).

[1]Probability figures are from Jackson (1963).

Hypothetical Model I:

In this model we assume that n (the total number of doves heard calling) remains the same (n = 100) and that the ratio of mated to unmated males (K) changes.

$$n = N_uP_u + N_mP_m \text{ and we let } N_m = KN_u$$
$$n = N_uP_u + KN_uP_m$$
$$n = N_u (P_u + KP_m)$$
$$N_u = \frac{n}{P_u + KP_m}$$
$$N_m = KN_u$$
$$N = N_m + N_u$$

Using the formulae above and using the probabilities determined by Jackson (1963) we have solved for the numbers of mated and unmated males in the population (Table 1).

TABLE 1. A MODEL ADULT BREEDING MOURNING DOVE POPULATION IN WHICH THE NUMBERS OF DOVES HEARD CALLING REMAINS CONSTANT (100) AND IN WHICH THE RATIO OF MATED MALES PER UNMATED MALE CHANGES FROM 1 TO 8.

Sex ratio (males per 100 familes)	200	150	133	125	120	117	114	112.5
Mated males per unmated male (K)	1	2	3	4	5	6	7	8
Number of unmated males (Nu) $Nu = \frac{n}{Pu + KPm}$	86	72	62	54	48	43	39	36
Number of mated males (Nm)	86	144	185	216	240	260	276	289
Total Males (N) $N = Nu + Nm$ To yield 100 males heard cooing	172	216	247	270	288	303	315	325
The per cent change in the male population due to an increase		+25	+14	+9	+7	+5	+4	+3
or decrease of one in K	−20	−13	−9	−6	−5	−4	−3	
The per cent change in the number of females in the population* due to an increase		+67	+28	+17	+11	+8	+6	+5
or decrease of one in K	−40	−22	−14	−10	−8	−6	−4	

* Assuming all females are mated

Here we noted that as the ratio of mated to unmated males increases, the size of the male element of the breeding population increases. The per cent change in the number of males declines rapidly, however, as the proportion of mated males increases.

Thus, in our population with a change in the matedness ratio of from 1 to 2 mated males per unmated male, there is a 25 per cent increase in the total male population when the numbers of doves heard calling remain constant at 100. However, a change in the matedness ratio of 6 to 7 mated males per unmated male results in a change of 4 per cent.

Hypothetical Model II:

In the second hypothetical model, we assume that the numbers of males in the population remain constant (N = 100). Here we are concerned with the changes in the total calls heard with varying ratios of mated per unmated male (K = 1 to 8 mated to unmated birds, Table 2). In this case, the number of males in the population that call (n) declines as the ratio of matedness increases. It may be noted that the per cent error resulting from changing matedness ratio decreases as the proportion of the males that are mated increases.

Female Population Levels:

The calculations in the above two models are based only on the male element of the breeding population; however, it should be emphasized that assuming most or all adult females are mated, the number of females in the population rises sharply as the matedness ratio increases. For example, in the first model where the per cent change in the population of males, resulting from a change of the matedness ratio from 4 to 5, is +7 per cent (Table 1), the change in the numbers of females in the population is +11 per cent $\left(\frac{240 - 216}{216} = .11\right)$. In both models, the percentage change in the number of females in the population is presented. The number of females represents the mates of the mated males in the population and it is assumed there are no unmated females.

In both cases, the error induced in the breeding population index from differing cooing rates of mated and unmated males becomes less as the matedness ratio increases. Thus, the magnitude of the error that results in the measurement of the breeding index each year is re-

TABLE 2. A MODEL ADULT BREEDING DOVE POPULATION, IN WHICH THE NUMBERS OF MALES REMAIN CONSTANT AT 100 AND THE RATIO OF MATED MALES PER UNMATED MALE INCREASES FROM 1 TO 8.

Sex ratio (males/100 females)	200	150	133	125	120	117	114	112
Mated males per unmated male (K)	1:1	2:1	3:1	4:1	5:1	6:1	7:1	8:1
Number of mated males (N*m*)	50	67	75	80	83	86	88	89
Number of unmated males (N*u*)	50	33	25	20	17	14	12	11
Number of mated males cooing (N*m*P*m*)	11	15	17	18	19	20	20	20
Number of unmated males cooing (N*u*P*u*)	47	31	23	19	16	13	12	11
Total males heard cooing (n = N*m*P*m* + N*u*P*u*)	58	46	40	37	35	33	32	31
Per cent change in the numbers of doves heard cooing due to an increase		−21	−13	−8	−5	−5	−4	−3
or decrease of one in K	+26	+15	+8	+6	+6	+3	+3	
Per cent change in the number of females in the population* due to an increase		+34	+12	+7	+4	+3	+2	+1
or decrease of one in K	−24	−11	−6	−4	−3	−2	−1	

* Assuming all females are mated

lated to the change between years in the ratio of mated to unmated males. If this ratio remained constant between years, errors from this source would not occur in the coo-call census population index.

Because of greater cooing rates among unmated males, the least amount of error will occur when the matedness ratios are high (*i.e.,* when the ratio of mated per unmated males is high). At present, methods to measure matedness ratios of breeding mourning doves do not exist. Therefore, indirect methods must be used. One such method is to study the sex ratios of adults, making the reasonable assumption that most females are mated. Thus, any excess males as indicated by the sex ratio, represent unmated males. This then allows a computation of a matedness ratio.

SEX RATIOS

Sex Ratios from Banding Data:

Sex ratio data are available from bandings of sexed adults and from dove hunter bag checks. In both cases, there are biases that favor adult males. In the case of sex ratios derived from banding data, the bias probably results from the combination of a nest attendance routine that finds the male off the nest during the hours normally associated with the highest trapping success (morning and evening hours). The female is off the nest during midday when trapping activity is lowest. Most of the sex ratio data available are from trapped samples of adults obtained in the breeding period, May through August. Another potential source of bias in sex ratios derived from banding data is due to the easily identified sex characters of the brightly-colored males, while classifying the drab-colored females as "sex unknown" in the banding records. The total of sexed adults from pre-season bandings (May through August) in all years through 1961 reveals that 26,222 adult doves have been banded with a sex identification. Of these, 15,182 were adult males and 11,040 adult females for an overall unweighted ratio of 138 males per 100 females (Table 3). If all females are assumed to be mated, the ratio of mated to unmated males (K) would be 2.62 to 1.

Sex Ratios from Hunter Bag Checks:

Another approach to an estimation of the sex ratio of the dove population is through sex identification of doves in the hunter's bag. Unfortunately, although much age data have been taken from bag checks and wing collections, little data have been compiled on the sex of hunter kills, especially by age groups. Chambers, Wight, and Baskett (1962) have summarized the data from a number of hunter-bag studies accomplished in the late 1930's and early 40's in North

TABLE 3. SEX RATIOS AND DIRECT RECOVERY RATES OF SEXED ADULTS BANDED IN PRE-SEASON PERIOD MAY THROUGH AUGUST, ALL YEARS TO 1961

Management Unit	Number banded		Sex ratio	Number direct recovery		Direct recovery rate		Relative recovery rate
	Males	Females		Males	Females	Males	Females	
EASTERN MANAGEMENT UNIT								
Hunting States	3,875	2,225	174:100	161	86	4.15	3.87	1.07
Nonhunting States	1,708	960	183:100	13	10	0.76	1.04	0.73
TOTALS	5,583	3,185	175:100	174	96	3.12	3.01	1.04
CENTRAL MANAGEMENT UNIT								
Hunting States	5,335	3,457	151:100	83	39	1.53	1.13	1.35
Nonhunting States	164	204	80:100	1	3	0.61	1.41	0.43
TOTALS	5,499	3,661	150:100	84	42	1.53	1.15	1.33
WESTERN MANAGEMENT UNIT[1]								
	4,100	4,194	98:100	159	140	3.88	3.34	1.16
GRAND TOTALS	15,182	11,040	138:100	417	278	2.75	2.51	1.10

[1] All States in Western Management Unit have hunting seasons.

Carolina and Alabama. From these data, an overall sex ratio of 114 males per 100 females was computed from averages of sex ratios from 8 samples in which 100 or more doves were examined.

One bias in the collection of sex ratios from shot samples, during the period November through March has been pointed out by Chambers *et al.* (1962) who compared the ratios of doves collected in northern Missouri (231:100), North Carolina (162:100), and Alabama (99:100). These data indicate that sex ratios collected in Northern States may be geographically biased due to a differential migration among sex and age groups in the dove population. The small amount of data suggests that southern states may have a more even sex ratio.

Hanson and Kossack (1963) present data on small collections of adult doves shot from September seasons in Illinois during the period 1948-56. The collections possibly combine the biases of nest attendance, and differential migration. The authors combined collections from northeastern and central Illinois (totaling 327 doves) and present an unweighted sex ratio for adults of 151 males per 100 females. The sex ratio for immatures from the same years (713 doves) was 113 males per 100 females.

Direct Recovery Rates of Sexed Adults:

An examination of the direct recovery rates of doves banded as sexed adults provides some interesting estimates of the sex ratio biases derived from shot samples. If we assume that adult doves are equally vulnerable to the gun, then in large samples of direct recoveries, the recovery rates of both sexes should be nearly equal. Any differences between the direct recovery rates for adult males and females is an expression of a differential vulnerability to the gun. This could be the result of an activity or behavioral pattern in relation to hunting, or as a result of differential migration.

In Table 3 we find that in the hunting states of the three management units, the adult males show a higher direct recovery rate than the adult females. This suggests that adult males are more apt to be shot than adult females. In the non-hunting states where shot recoveries can occur only after the birds have migrated to a hunting state, the recovery rates for adult males are considerably less than for adult females. This latter finding lends additional support to the contention that adult males are less migratory or migrate at different times than do adult females, and this results in a lower vulnerability to the gun for the males banded in non-hunting States.

For the entire United States, the unweighted direct recovery rate for adult males is 10 per cent higher than for females, and this figure can be expressed as a relative recovery rate of 1.10 (i.e., adult males are 1.10 times more vulnerable to the gun than adult females, $\frac{2.75}{2.51} = 1.10$).

For the Eastern Management Unit, this ratio is 1.07; for the Central Unit, 1.33; and for the Western Unit, 1.16. A correction for greater vulnerability of males in adult sex ratio data (derived from hunter bag checks) is possible. This can be accomplished by dividing the numbers of males per 100 females in the adult sex ratio by the relative recovery rate for adult males in the population.

In summary, it may be stated that sex ratios of adults derived from pre-season bandings, and from hunter bag checks are subject to biases that favor adult males. Immature sex ratios do not appear to contain these biases to the same degree.

Mourning dove populations undoubtedly contain an excess number of males, but at present, unbiased estimates of the sex ratio of populations of mourning doves from banding and hunter bag data are not available.

ESTIMATION OF SEX RATIOS FROM MORTALITY AND PRODUCTION DATA

In the absence of unbiased adult sex ratio data, we must resort to indirect methods to estimate the matedness ratio in the mourning dove breeding population. To do this, we shall utilize mortality rates derived from banding data and production estimates. This approach is based on the fact that in a population with fixed mortality and production rates, the sex ratio of adults rapidly stabilizes, and this value may be predicted.

Intuitively, it could be reasoned that if mortality rates are higher for adult females than adult males over a number of years, the sex ratio of the dove population would increasingly favor the males. This is true up to about 5 years, but by this time the sex ratio has nearly stabilized. This can be demonstrated by assuming a population of 100 males and 100 females with a production of 4 fledged young per adult female. We shall apply a 50 per cent mortality to adult males, 60 per cent mortality for adult females, and a 70 per cent mortality for immatures. Further, let us assume an even sex ratio among the young. At the end of the first year the sex ratio will be 110 males per 100 females. At the end of the second year the sex ratio is 115 males/ 100 females. At the end of the third year, 117.5; the fourth, 118.75; and the fifth, 119.37. By the tenth year the adult sex ratio is only 119.98 males per 100 females. Thus, the sex ratio reaches a theoretical limit beyond which it will not go if all of the given population characteristics remain the same. This theoretical limit is termed the asymptote of the sex ratio of the population. For each set of population characteristics given to a hypothetical population, an asymptote value may be calculated beyond which the sex ratio will not displace.

This value may be compueted using the formula devised by Robert Heath, Division of Wildlife Research Biometrician (Wight, Heath. and Geis, in press) as follows:

$$R' = \frac{P'S_b}{FS_a - MS_a + P'S_b}$$

where R' = the sex ratio asymptote
P' = ½ the production of fledged young per adult female
S = survival rate = (1- annual mortality rate)
F = female
M = male
a = adult
b = immature

Two elements of this discussion of asymptotes of adult sex ratios are important in considering the effect of differential cooing rates of adult males on the results of the coo-call census. One, the sex ratio of adults can only be displaced a certain amount by a differential in the adult mortality rates assuming constant production per adult female; and, two, the displacement of the sex ratio will be relatively small based on our present knowledge of the mortality rates of the adult sexes and of production estimates.

Mortality Rates:

Preliminary estimates of the difference between mortality rates of adult females and males indicate that males have a rate about .06 less than that of females.

Limited mortality rates can be ascertained from recoveries of adults sexed and banded during the pre-season banding period. In all cases, the mortality rates are highest in females (Table 4). Several of the States are represented by data with small samples of recoveries and until greater sample size is obtained, these mortality data should be considered only as tentative results. Differences between mortality rates of adult males and females vary considerably; but in states with the largest samples of recoveries for both sexes, (Louisiana and Arizona) the mortality rates of females are only slightly higher than those of males.

Using data from the Southeastern Dove Study Report (1957), we may obtain an estimate of the first-year mortality for immatures of 70 per cent. This figure agrees closely with an average of the immature first-year mortality rates of 72 per cent for 5 states in the Eastern Management Unit with sufficient recoveries (25 or more) during the period 1949-1960.

Production:

Production data are available from many nesting studies or from age ratios in the hunter's bag corrected for differential vulnerability of immatures and adults. For the purpose of estimating the sex ratio asymptotes of a mourning dove population, we may again use data available to us from the Southeastern Dove Study Report (1957). This report presents age ratio data from States with September hunting seasons in the period 1949 to 1955, inclusive. These rata averaged 70.3 per cent juveniles or 236.7 immatures per 100 adults. A recent analysis of banding data from the Eastern Management Unit of doves banded during the pre-season period, revealed a relative recovery rate of 1.5 immatures per adult. By dividing the number of young per 100 adults by the relative recovery rate $\frac{236.7}{1.5}$, we obtain the number of young in the population per 100 adults (157.8). Assuming an equal sex ratio in the population, we would use twice this figure or 315.6 young per 100 adult females.

Matedness Ratio Estimates:

Using the available mortality and production data, it is possible to make some preliminary estimates of sex ratios of adults. These sex ratios represent average ratios since the component data were averages.

As indicated previously, only 4 states (Table 4) had sufficient data from which annual average mortality rates for both sexes of adults could be calculated. Only Louisiana can be termed an Eastern Management Unit state.

Using Louisiana's data showing a .039 difference between adult male and female mortality rates, and the production figure calculated

TABLE 4. ANNUAL AVERAGE MORTALITY RATES OF SEXED ADULT MOURNING DOVES (FROM COMPOSITE DYNAMIC LIFE TABLES)

State	*Adult Males*	*Adult Females*
Missouri	41.3% (109)[1]	56.5% (45)
Louisiana	58.0% (178)	61.9% (80)
New Mexico	56.25% (31)	59.7% (13)
Arizona	55.1% (194)	57.25% (155)
AVERAGE	52.7%	58.8%

[1] Numbers in parentheses indicate sample size.

from the Southeastern dove study, we can apply the sex ratio asymptote formula and determine an adult sex ratio of 109 males per 100 females. Assuming all adult females are mated, the mated to unmated male ratio is 11:1.

If we use the average of the 4 states' mortality data, there is a difference of .061 between the mortality rates of sexed adults and we may calculate an adult sex ratio of 114 males per 100 females and a matedness ratio of 7:1.

Estimations of the adult sex ratios for the Central and Western Management Units must await production and mortality estimates; however, it appears that the mortality rates of adults will be similar to that of the Eastern Unit, but the immature mortality rates of the Central and Western Units will probably be lower. Average production per adult female will probably be much the same throughout the range of this species. Therefore, our best preliminary estimates of the characteristics of the continental dove population would be: A production rate of 3.0 young per adult female, a first year survival rate for immatures of 35 per cent, a survival rate for adult males of approximately 50 per cent, and for females, 45 per cent. These population characters result in a sex ratio of 110 males per 100 females, and a matedness ratio of 10 mated males per unmated male.

ACKNOWLEDGMENTS

I wish to express my appreciation to Gary Jackson, Missouri Cooperative Wildlife Research Unit, for his permission to use unpublished data on probability of cooing of mated and unmated doves. Harold Irby, Arizona Cooperative Wildlife Research Unit, and Lytle Blankenship, Migratory Bird Populations Station, allowed me to review unfinished studies on cooing behavior which contributed to my understanding of the problem. Aelred Geis, Migratory Bird Populations Station, assisted in the preparation of the manuscript, and Robert Heath, Patuxent Wildlife Research Center, assisted in the mathematical treatment of the data.

CONCLUSIONS

Estimates of the biases in the coo-call census that result from differing cooing rates of mated and unmated male doves during the census period require:

1. An estimate of the ratio of mated to unmated males in the population.
2. A measurement of the changes in this ratio that may occur from year to year.

At the present time, we do not have a method of estimating the latter. Estimates of the matedness ratio, however, can be indirectly deduced from data collected for other purposes. Changes in the ratio (in the expected range) can be used to suggest the magnitude of biases in the coo-call census should such changes in matedness ratios occur.

We conclude therefore, that estimations of matedness ratios, based on the assumption that few adult females will be unmated, derived from sex ratios from banding data or hunter bag samples are biased in favor of males. This bias is inherent in the behavior of the mourning dove.

An alternate approach to determining the expected range of matedness ratios in wild dove populations is through adult sex ratios derived from mortality and production data. Adult females usually have higher annual average mortality rates than do males. It has been shown that the displaced sex ratio arising from such a condition can be predicted when a uniform production rate per adult female and a constant immature mortality rate are assumed. Calculations based on preliminary data suggest that the adult sex ratio should stabilize at approximately 110 males per 100 females. At this sex ratio, matedness ratios would be 10 mated males per unmated male. Fluctuations of matedness ratios in this range would have little influence on the census results.

By the use of hypothetical models, I have shown that changes in matedness, where the sex ratios of the adult segment of the population approach equality, will not significantly affect the results of the coo-call census.

Greater insight into this problem awaits further banding and production data. In the meantime, using the limited data available, it would appear that the expected matedness ratio of the dove population over much of the range will be such that the bias due to differing calling ratios among mated and unmated males does not greatly alter the capability of the dove coo-call census to measure annual trends in the mourning dove breeding population.

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REFORESTATION AND QUAIL MANAGEMENT AT FORT CAMPBELL, KENTUCKY

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The practice of reforestation is being carried out over the entire country with increasing intensity. Species planted are generally the various pines. Reforestation in certain areas supplements efforts to increase game populations. However, in the southeastern part of the country where "Bob White" reigns supreme, this is not necessarily true. In this area the cries of verbal battle between game biologists, foresters, quail hunters and field trial enthusiasts are frequently heard.

It is the purpose of this paper to illustrate the effects of reforestation and site preparation on quail harvest over a ten year period.

DESCRIPTION OF AREA

The Fort Campbell Military Reservation consists of approximately 105,000 acres of land located in Kentucky and Tennessee. The reservation is located 16 miles south of Hopkinsville, Kentucky and 8 miles north of Clarksville, Tennessee. The topography is generally flat and rolling land except for the western portion of the post where the topography becomes more broken. Generally speaking, soils are limestone derived and consist mainly of the following series: Hagerstown, Decatur and Baxter. These soils are among the best agricultural soils in this region. Prior to acquisition by the Army in 1940 and 1941 the land was used for the production of tobacco, corn, small grains

[1]In the absence of the author the paper was read by Mr. Calvin Barstow.

and pasture. The total woodland acreage is approximately 27,000 acres of second growth hardwood forest, occurring mainly in small blocks 2 to 40 acres in size. These tracts are widely scattered over the entire area.

POST HISTORY OF REFORESTATION EFFORTS

Reforestation efforts were started in 1954 on the Fort Campbell Military Reservation. The areas designated for planting were narrow strips of old fields located adjacent to privately owned land. Spacing was 6 feet by 6 feet or approximately 1,000 plants per acre. This spacing was recommended by the various federal and state agencies involved in reforestation efforts. Approximately 12,000 acres are in pine plantations with sufficient stocking at the present time. It is planned to reforest 12,000 more acres for a total of 24,000 acres of pine plantations.

COLLECTION OF KILL DATA

All hunting at Fort Campbell is on a controlled basis. Specific areas are assigned to each hunter or group of hunters. Because of safety problems it is mandatory that personnel check in and out after each day's hunt. At this time kill data is also reported. Ten years of kill data on 52 separate hunting areas has been collected. This data along with forestry management records are used in making the evaluations found in this paper.

EFFECTS OF PAST REFORESTATION ON QUAIL HARVEST

To determine the effects of past reforestation on quail harvest two training areas were selected. One area was reforested, the other contained no pine plantings. The reforested area was planted to loblolly pine in 1955. At the present time the reforested area contains 115 acres of second growth hardwood forests, 777 acres of pine plantations and 309 acres of open land for a total acreage of 1201. The unreforested area contains 292 acres of hardwood forest and 1,214 acres of open land for a total acreage of 1,506. The two areas are separated one from the other by a fifty foot gravel road.

Referring to Figure 1 titled, "Quail Harvest on a Reforested Area Versus an Unreforested Area," it is noted that the harvest in both areas was more or less similar for the first seven or eight years following reforestation. The harvest per 1,000 acres in the reforested area dropped very sharply after the eighth growing season for the loblolly pine. At the present time many of the pine plantations are 4 inches diameter breast high and 15 feet in height. A mulch has been formed under the pine and much of the lesser vegetation has

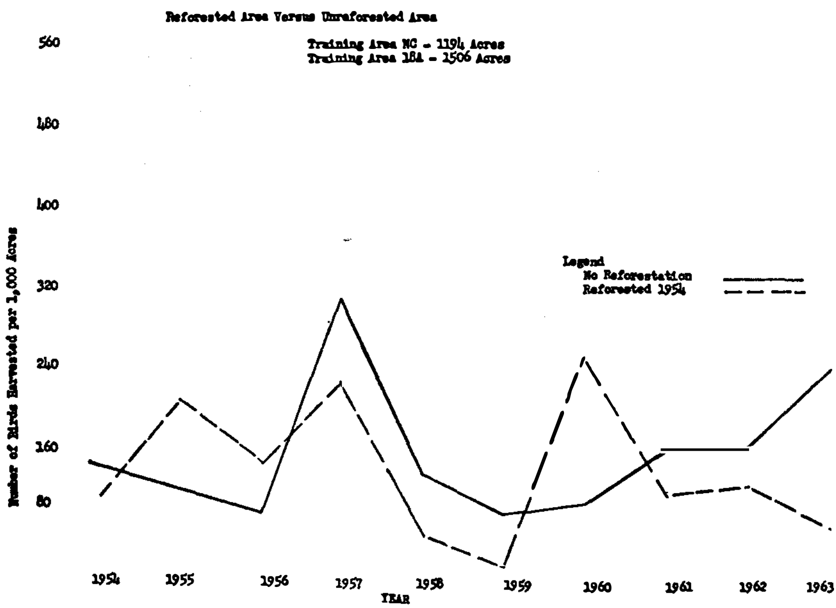

Figure 1

been eliminated. The unreforested area shows a sharp rise in number of birds harvested for the same period.

PRESENT AND FUTURE REFORESTATION TECHNIQUES AND PLANS

The present reforestation technique consists of dividing each training area into 60-acre blocks. Twenty-foot graded trails divide each training area in a checkerboard pattern. Alternate 60 acre blocks are then cleared with K-G blades, bush and bogged, and planted with pine on a 6-foot by 12-foot spacing. Only brush areas are cleared. Blocks of second growth hardwood timber are not cleared. Blocks where no pine is planted are opened up to the maximum and maintained in an open condition.

The technique as described above was primarily developed to insure that conditions favorable to troop training operations were maintained. The many miles of firebreak trails provides maximum access for troop training operations. The checkerboard pattern of forested and open areas provides a pattern of vegetative cover which aids troop training efforts. The 6-foot by 12-foot spacing permits good access and after the first thinning a 12-foot by 12-foot spacing will give a closed-canopy park like effect. These areas will provide cover and concealment for military training operations on a year round basis. Hardwood stands provide little concealment for military operations during the dormant period.

The present technique provides maximum control of forest fires. Open and brush areas of blocks not planted to pine are controlled burned every other year. The resulting pattern of firebreaks and areas with reduced fuel produces conditions which retard wildfires to the maximum. Pyro-techniques and other fire causing training devices can continue to be used despite high fire danger.

The alternate 60-acre blocks which are not planted in pine offer ideal conditions for quail. Prescribed burning in these small blocks can be practiced on a more intensive scale. More intense fires can be prescribed since the fire will be confined to a relatively small area and can easily be controlled even when burning on high fire danger days. Hot fires are required to kill larger stands of brush. Plant succession can be more effectively retarded with a subsequent increase in the quality and quantity of quail habitat. The unplanted blocks become the focal point of intense quail management with fire and land clearing equipment being the major tools for the development and improvement of quail habitat.

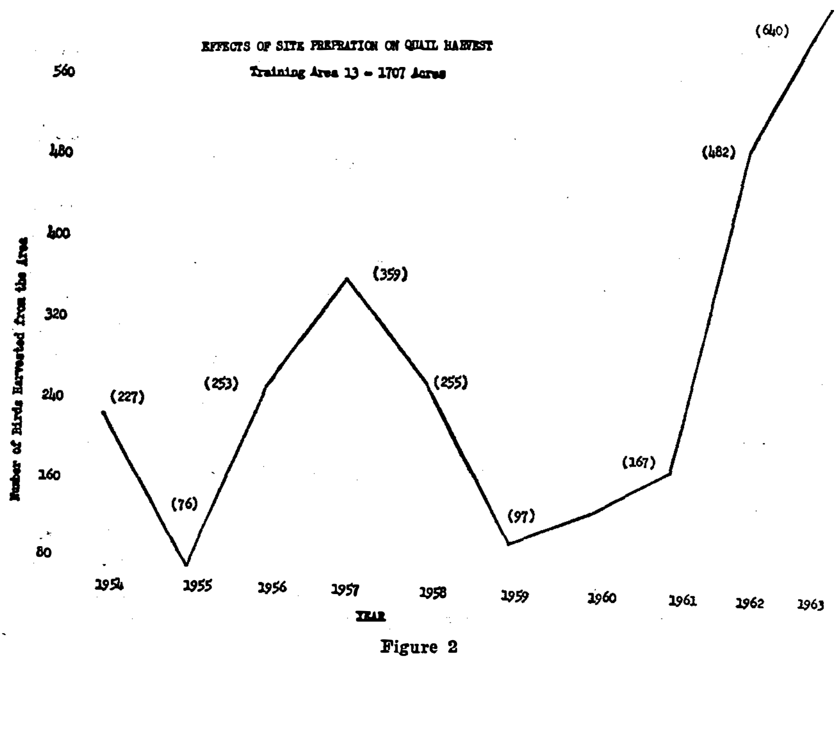

Figure 2

In May and June, 1962 this area was prepared using the checkerboard technique. Heavy brush was removed with D-8 caterpillar tractors equipped with Rome K-G clearing blades. Small scattered patches of brush were disced with heavy ground preparation discs. In 1963 the prepared blocks were planted to pine. In late summer 1963 the unplanted blocks were prepared for control burning. Control burning of these blocks was accomplished in November, 1963 prior to the start of the hunting season.

Referring to Figure 2 titled, "Effects of Site Preparation on Quail Harvest," it is noted that the number of birds harvested increased sharply during the 1962 hunting season. In 1962 the number of birds harvested from the area was 640 or one bird bagged per every 2.6 acres.

EFFECTS OF MECHANICAL SITE PREPARATION ON QUAIL HARVEST

Use of the checkerboard reforestation technique was first initiated in 1962. The first area so prepared was training area 13. This area contained 364 acres of second growth hardwood forest and 1,343 acres of brushland with scattered openings. The brush had reached such a size that normal control burning operations had little effect upon it.

SUMMARY AND CONCLUSION

1. The quail harvest on reforested areas does not decline greatly until seven to eight years after planting. At this time the harvest per thousand acres declines rapidly. This decline will probably continue until pine harvesting operations are begun.
2. Mechanical site preparation prior to reforestation greatly improves quail habitat. The increased production for a few years afterwards helps to balance out years of low productivity which will occur as the planted plantations grow larger.

It is readily apparent that at least minor modifications in reforestation techniques must be made to maintain some habitat which will produce huntable populations of quail. The economical benefits derived from pine plantations usually cause the production of wood fiber to be placed at a higher level than the production of quail. However, by the skillful application of various land management tools such as prescribed burning, mechanical site preparation, and harvesting methods the forester or land manager can produce maximum fiber along with huntable populations of quail.

DISCUSSION

DISCUSSION LEADER GLAZENER: Thank you, Calvin.

We, for many years, have been interested in some of the fantastic reports on

quail harvest at the Fort Campbell Reservation and we have some relatively up-to-date data from that area.

It would be interesting to know some of the economics involved were a similar program instituted on privately owned lands.

MR. O. EARLE FRYE (Florida): First of all, I want to commend the Army for doing a real good job of putting a proper quail management technique into another major land use. However, I am particularly interested in the methods by which the birds are harvested. Who are they shot by—how is all this handled and, furthermore, is it anywhere near self-supporting insafor as operation of the hunt is concerned?

MR. BARSTOW: I should not have given the paper. You caught me short. Perhaps Fred Stanberry or Harold Warbell are more familiar with this than I, but I believe it is done on an invitation basis, whereby you have to go with one of the soldiers on the post.

MR. FRED STANBERRY (Tennessee): This is partly true. They changed their method, and they are a little more liberal than they were at one time insofar as hunters in particular areas are concerned.

As to the cost, we have no figures at all. This is all done by military personnel. You might say they run the show.

There is no charge for the hunters, per se. They have what is known as a club there. Most of the members on the post belong to it. People who hunt there, I believe, subscribe to membership in it, and money from this goes into the management of the area.

MR. GENE OREN (Department of the Army, Washington): I know a little bit about this Fort Campbell situation.

One thing that should be remembered is that this is a highly productive limestone soil area and this controlled burning in a checkerboard pattern is done to maintain open areas for the airborne outfits that operate there. Therefore, the cost of that should not be charged against wildlife.

Now, following a controlled burn, the first year, they get an intense stand of ragweed and annual growth. During the second year, the annual growth takes over exclusively. The blocks are burned at different times and I believe this is the secret to their high population of quail rather than what they do or do not do about planting the trees.

Also, most military reservations charge a nominal fee for hunters and this money is plowed back into the program. However, we try to operate the land use management in such a way to facilitate first the military operation and derive the by-product benefit for wildlife from the primary operation.

MR. GLAZENER: This is a modification of the multiple use purpose under specialized conditions that are paying off. Thank you again.

BIASES IN A MAIL QUESTIONNAIRE SURVEY OF UPLAND GAME HUNTERS

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Chapman, *et al.* (1959) described three broad types of error that can affect the accuracy of surveys designed to obtain hunting statistics. These were sampling error, response errors and non-response error. Sampling error results when the sample of contacts is not representative of the universe of interest and is probably minimal when proper sampling techniques are used. Response errors in mail questionnaire surveys of hunters have been recognized as one of the major problems in that method of obtaining hunting statistics (Atwood, 1956; Cronan, 1960; Hayne, 1964; Robertson, 1958). Investigators have found that hunters tend to report more hunting activity and better success than they actually experienced with the response errors thus incurred resulting in a positive bias affecting the data collected. Atwood (op. cit.) discussed three types of response errors in a study of survey reporting by waterfowl hunters. The two most apparent of these errors he called "Prestige Bias" and "Memory Bias I." "Prestige Bias" reflected the tendency of the respondent to report his kill in multiples of the daily bag limit and "Memory Bias I" presumably occurred when the respondent guessed his seasonal kill (because of a lack of records) and was evidenced in digits ending in "0" or "5." A bias attributable to non-response error can occur in mail questionnaire data because survey returns seldom equal 100 per cent. If there is no difference between the hunting success or characteristics of the hunters who return questionnaires and those who do not, there will be no error due to non-response. However, if the hunting characteristics of the respondents and non-respondents differ (and this may often be the case: Eberhardt and Murray, 1960; Hayne, 1964; Roberston, 1958), it is not valid to consider the data from the questionnaire returns representative of the entire hunter population. The purpose of this paper is to report the occurrence of biases attributable to response and non-response errors in a mail survey of upland game hunters.

METHODS

Spring Valley Wildlife Area, in southwestern Ohio, was selected for this study because comprehensive hunter records were collected there

[1]In the absence of the authors, this paper was read by Mr. Walter Crossey.

for several years and compulsory checking was planned again for the 1961-62 hunting season.[1]

Field records for hunters using the Area were kept in the following manner: A hunter's name and address were taken when he checked into the Area to hunt; his hunting time and kill of game were entered on his file card when he left the Area. Similar data were recorded on his file card each time the hunter visited the Area thereafter. Thus, it was possible to determine the number of trips made to the Area and the game killed by any hunter from the file of field records.

A questionnaire was mailed to each hunter after the close of the hunting season in January 1962. The hunters were requested to report the number of times they hunted on the Spring Valley Area and the numbers of pheasants, rabbits, and quail they killed. It was emphasized on the questionnaire that we wanted information pertaining to hunts on the Spring Valley Wildlife Area only and that hunting results on other state-owned areas or private lands were not to be included. When returns from the first mailing of questionnaires ceased to come in, a second questionnaire was sent to the hunters who had failed to reply. This procedure was repeated a third time and, when the daily returns from that mailing neared zero, the questionnaire data were tabulated.

The study data were as follows:

Hunters that used the Spring Valley Area during the 1961-62 season	= 5,016
Hunters that did not check through the checking station when they left the Area	= 10
Total FIELD RECORDS	= 5,006
Name and addresses that were not legible NON-DELIVERABLE	= 35
Questionnaires mailed	= 4,971
Questionaires returned by the Post Office as non-deliverable—NON-DELIVERABLE	= 392
Questionnaires presumably delivered	= 4,579
Questionnaires returned—RESPONDENTS	= 3,475[2]
Questionnaires delivered but not returned—NON-RESPONDENTS	= 1,104

[1]Hunting on the Spring Valley Wildlife Area is probably not representative of hunting in Ohio. The majority of the hunters (80-90 per cent) originate within a 30-mile radius of the Area which includes the Dayton and Cincinnati metropolitan areas. Hunting pressure is extremely high and tends to depress individual success. Furthermore, the pheasant kill is composed primarily of game farm raised birds released on weekends and holidays to draw hunting pressure from private lands. Hence, the kill per hunter of rabbits and quail is inordinately low.

[2]These questionnaires all provided data about game kill but only 3,267 of them provided useful data concerning hunting trips.

The data used in the analysis included the reported data from the questionnaires and various groupings of the statistics contained in the field records. Statistical tests for significance of findings were done with methods described by Bailey (1959). These tests are similar to the "t" test but applicable for large sample sizes only. Statistical significance is indicated in the tables with one asterisk(*) for the five per cent level and two (**) for the one per cent level of probability.

RESULTS

Table 1 contains the data concerning hunting trips and game kill from the Spring Valley field records and the corresponding statistics reported on the questionnaire. The totals for hunting trips and game killed for the field records are known statistics. The totals for the questionnaire data are estimates derived in the usual manner that survey data are expanded; viz., by multiplying the average number of hunting trips or game killed per hunter by the total number of hunters (5,006).

These data show that the questionnaire data yielded total estimates of hunting trips and game killed that were markedly higher than the known statistics. In general, it appeared that the size of the error was inversely related to the magnitude of an item. For example, the per cent difference between the known total and the corresponding questionnaire estimate was much higher for quail killed than for pheasants killed.

The total difference or error between the known field records and the estimates derived from the questionnaire data was calculated so that portions could be assigned to response and non-response errors (Table 2). The allocation of error was made on the basis of the following assumptions:

1. That the total error was the difference between the estimates from the questionnaire data and the totals from the total field records.
2. That the portion of the total error attributable to response errors was the difference between the estimates from the questionnaire data and the estimates from the field records of the respondents.

TABLE 1. A COMPARISON OF HUNTING STATISTICS TAKEN FROM THE KNOWN FIELD RECORDS AND QUESTIONNAIRE DATA FROM THE SPRING VALLEY WILDLIFE AREA, OHIO, 1961-62

	Field Records		Estimates From Questionnaire Data		Difference or Error	
	Mean	Total	Mean	Total	Total	Per Cent
Hunting trips	1.351	6,764	1.657	8,295	1,531	23
Pheasants killed	0.394	1,970	0.529	2,648	678	34
Rabbits killed	0.085	427	0.155	776	349	82
Quail killed	0.030	153	0.062	310	157	103

TABLE 2. HUNTING STATISTICS AND ESTIMATES FROM KNOWN FIELD RECORDS AND QUESTIONNAIRE DATA FROM THE SPRING VALLEY WILDLIFE AREA, OHIO, 1961–62

	Total Field Records	Respondents Field Records[1]	Questionnaire Data[1]
Hunting trips	6,764	6,988	8,295
Pheasants killed	1,970	2,142	2,648
Rabbits killed	427	466	776
Quail killed	153	160	310

[1] Estimates

3. That the portion of the total error attributable to non-response error was the difference between the estimates from the respondents field records and the totals from the total field records.

Table 3 contains the allocation of total error for response and non-response errors. These data show that the proportion of error in the estimates from the questionnaire data was greater for response errors than for non-response. This relationship varied among reported items and appeared to be greatest for the estimate of quail killed (96 per cent) and least for the estimated number of pheasants killed (75 per cent). The results suggest that the importance of response errors overshadowed that of non-response. However, error due to non-response was about 9 per cent of the known kill of pheasants and rabbits. Therefore, it appeared that important biases attributable to both response and non-response errors occured in the estimates made from the questionnaire data.

The significance of the response error was tested assuming the response error was the difference between the data reported on the questionnaire and the known data for the respondents. Table 4 contains a comparison of the questionnaire data with comparable field records for those individuals who returned questionnaires. The comparison shows that the difference between the means of the questionnaire answers and comparable field records was significant at the 1 per cent level of probability for all reported items. In other words, the hunters reported significantly more trips and game killed than

TABLE 3. THE ALLOCATION OF TOTAL ERROR FROM THE QUESTIONNAIRE DATA ESTIMATES

	Portions of Total Error				Per Cent of Known Trips or Kill	
	Response		Non-response		Response	Non-response
	Error	Per Cent	Error	Per Cent	Error	Error
Hunting trips	1,307	85.4	224	14.6	19.3	3.3
Pheasants killed	506	74.6	172	25.4	25.7	8.7
Rabbits killed	310	88.8	39	11.2	72.6	9.1
Quail killed	150	95.5	7	4.5	98.0	4.6

TABLE 4. A COMPARISON OF THE MEANS OF HUNTING STATISTICS FROM THE QUESTIONNAIRE DATA AND THE FIELD RECORDS OF THE RESPONDENTS DEMONSTRATING RESPONSE ERROR

	Questionnaire Answers		Comparable Field Records		Difference Between Means
	Mean	Variance	Mean	Variance	
Hunting trips	1.657	2.380	1.396	1.717	0.261**
Pheasants killed	0.529	1.875	0.428	1.283	0.101**
Rabbits killed	0.155	0.438	0.093	0.129	0.062**
Quail killed	0.062	0.194	0.032	0.064	0.030**

was actually the case. This inaccurate reporting by the respondents resulted in a positive bias in the questionnaire data.

The proportion of total error attributable to non-response was the difference between the totals of trips and game killed in the overall field records and the estimates calculated from the field records of the respondents. The differences between the means of those two groups of data were significant for hunting trips, pheasants and rabbits killed (Table 5). However, the error thus tested was actually effected by two groups of hunters. One group was the "true" non-respondents, or those individuals we assumed received a questionnaire but had not returned it. The second group was those hunters who had not been contacted because their names and/or addresses were not legible on the field records or the questionnaires sent them were returned as non-deliverable by the Post Office. Both of the latter groups were classified as non-deliverable. Our primary interest was in determining if the hunting characteristics of the hunters who returned questionnaires were similar to those of the hunters who were contacted but failed to respond. The results of the comparisons of means in Table 6 indicate that the "true" non-respondent group of hunters made significantly fewer hunting trips and killed less game than the respondents. The hunters whose questionnaires were non-deliverable apparently made fewer hunting trips but killed similar numbers of game as did the respondents. It seemed then, that the estimates derived from the questionnaire data contained a positive bias attributable to the non-respondent segment of the survey contacts. Furthermore, an impor-

TABLE 5. A COMPARISON OF THE MEANS OF THE TOTAL FIELD RECORDS AND THE FIELD RECORDS OF THE RESPONDENTS SHOWING ERROR DUE TO NON-RESPONSE

	Total Field Records	Respondents Field Records		Difference Between Means
	Mean	Mean	Variance	
Hunting trips	1.351	1.396	1.717	0.045**
Pheasants killed	0.394	0.428	1.283	0.034**
Rabbits	0.085	0.093	0.129	0.008**
Quail killed	0.030	0.032	0.064	0.002

TABLE 6. COMPARISONS OF THE RESPONDENTS FIELD RECORDS WITH THOSE OF THE NON-RESPONDENTS AND NON-DELIVERABLE GROUP DEMONSTRATING NON-RESPONSE ERROR

	A		B			C		
	Respondents Field Records		Non-respondents Field Records		Difference Between Means	Non-Deliverable Group Field Records		Difference Between Means
	Mean	Variance	Mean	Variance	(A–B)	Mean	Variance	(A–C)
Hunting trips	1.396	1.717	1.245	0.319	0.181**	1.297	0.777	0.099*
Pheasants killed	0.428	1.283	0.295	0.915	0.133**	0.363	0.860	0.065
Rabbits killed	0.093	0.129	0.058	0.097	0.035**	0.096	0.143	0.003
Quail killed	0.032	0.064	0.023	0.051	0.009	0.037	0.088	0.005

tant part of this bias was due to an apparent direct relationship of an individual's hunting success to the probability of his returning the questionnaire.

DISCUSSION

The results of this work showed that a bias attributable to response errors and a lesser, but significant, bias due to non-response error occurred in the questionnaire data estimates. It appeared that the estimated kill of game was in greater error than the number of hunting trips (see again Tables 1 and 3). Atwood's (op. cit.) findings concerning "Prestige Bias" suggested that hunters might tend to over-report their kill of game to a greater degree than the number of times they hunted. However, the error affecting the estimated kill of pheasants, presumably the prestige species on the Spring Valley Area, was less than that affecting either of the estimated kills for rabbits or quail (Table 1). Furthermore, the proportion of the error in the pheasant kill estimate attributable to response was less than that for the other species killed as well as for hunting trips (Table 3). Because the per cent of error for the estimate of pheasants killed showed that the affect of non-response was more important than for other reported items, one might conclude that the hunters who succeeded in killing one or more pheasants were more apt to return their questionnaires than individuals who did not. Thus, it may be that a prestige influence affected biases resulting from non-response as well as from response errors.

The non-respondent portion of sample contacts in mail questionnaire surveys commonly includes those hunters who are contacted but fail to reply and a group for whom questionnaires are non-deliverable. We felt that the hunting characteristics of the non-deliverable group probably would not differ much from the total population of Spring Valley hunters. Actually, this group did not differ markedly from the respondents (Table 6). As a consequence, the bias due to non-response was attributed to the "true" non-respondents and it was concluded that the less successful hunters did not return questionnaires as readily as their more fortunate cohorts. The latter phenomenon has been suspected by many biologists and demonstrated by Hayne (op. cit.) and Robertson (op. cit.) among others.

In conclusion, the data collected in this study showed that the hunters who reported their hunting results over-reported their hunting activity as well as their kill of game and also that they made more hunting trips and were more successful than the hunters who did not report. The combination of inaccurate reporting and reporting by a group not representative of the total hunter population resulted in estimates of hunting trips and game kill from the questionnaire data that were significantly higher than the known statistics.

SUMMARY

Field records were kept for hunters using the Spring Valley Wildlife Area in Ohio during the 1961-62 hunting season. Questionnaires, asking about hunting trips and upland game killed, were sent to these hunters after the hunting season. Hunting trip and game kill estimates derived from the questionnaire data were higher than the known totals for those items. Comparisons of the data in the field records and the questionnaire data showed that errors attributable to response and non-response inaccuracies occurred in the questionnaire data. Response errors occurred because hunters reported killing more game and making more hunting trips than they actually did; non-response errors occurred because the non-respondents were less persistent in their hunting effort and killed less game than the hunters who did report. These errors resulted in positive biases in the hunting trip and game kill estimates made from the questionnaire data.

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DISCUSSION

DISCUSSION LEADER GLAZENER: Thank you very much, Walter. When you go hunting and fill out a questionnaire, you can be sure that your sins will be found out.

Second, a suggestion for correction factor. Had they inserted a question on how many shots the hunter fired, I think is would have brought it back down to probably a correct figure.

Now then, are there any serious questions?

MR. GILBERT HUNTER (Colorado): We have done considerable work along line, as Walt well knows. We have always found this—that when we send out a mail questionnaire, it varies from five to fifteen per cent higher than our actual check in an area. Therefore, I am quite skeptical myself of random surveys because I do not believe they catch small units.

For example, when we were running a random survey on small game, we had a county where very few people lived and when we got those questionnaires back it indicated, after we had projected it, that all the hunters in Jackson County went to another county to hunt pheasant. This is ridiculous because right over the hill from Jackson County is one of our best pheasant areas in the state. However, in that case, they went some 400 miles to hunt.

This just brings out the weakness of a random sample. Therefore, unless you have a very good sample, I don't think you accomplish much good.

Now, I would like to know the exact percent of kill that these authors said the random was of the actual check.

MR. CRISSEY: Well, the kill very considerably, depended on the species and on the number of trips reported.

Of course, we ourselves have various estimating responses. For example, in relation to our waterfowl surveys, the usual response error, at the least level of response, has been in the neighborhood of 30 to 40 per cent. Now, quite regularly, these response errors have been greater. However, I still think there is a degree of error involved with when the hunters report their kill on other than the specific areas they are asked to report in relation to.

ASSOCIATION OF PHEASANTS WITH VEGETATIVE TYPES IN EAST-CENTRAL ILLINOIS

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The ring-necked pheasant (*Phasianus colchicus*) occupies a variety of habitats within its range in North America, but is most numerous in areas characterized by fertile agricultural land. In Illinois, as elsewhere, pheasants are most abundant in areas intensively cultivated for cash-grain crops (Robertson, 1958:13); pheasants are most numerous in the cash-grain region of the east-central portion of the state (Greeley *et al.,* 1962:14-15).

Although vegetation is a primary component of the pheasants' cultivated habitat, little is known (except for studies of nesting ecology) about the actual utilization of various components of the vegetative complex by pheasants. This paper reports on the association of pheasants with various vegetative types, relative to their proportionate availability, during winter, spring, and summer, 1957-59, in east-central Illinois.

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STUDY AREA

All data were collected from a 23,200-acre tract (nearly 37 square miles) of farmland located near Sibley, Ford County, east-central Illinois. This tract of land lies within the most important cash-grain area in the corn belt; in 1950, 71 per cent of all farms in Ford County were classified as cash-grain farms, 13 per cent as general farms, and 10 per cent as livestock farms (Ross and Case 1956:45). About 95 per cent of the area was cultivated during the late 1950's; corn (*Zea mays*) and soybeans (*Glycine max*) occupied annually about 50-60 per cent of the total land area. Livestock farming was limited primarily to production of hogs or feeding of beef cattle; a few farms had small herds of dairy cattle.

The general cropping system involved a 4-year rotation: corn or soybeans, 2 years; small grains (mainly oats, *Avena sativa*), 1 year; tame grasses and legumes, 1 year. Included among tame grasses and legumes, which were seeded with small grains, were: timothy grass (*Phleum pratense*), smooth brome grass (*Bromus inermis*), yellow sweet clover (*Melilotus officinalis*), red clover (*Trifolium pratense*), and alfalfa (*Medicago sativa*). The grass-legume crops (hereafter referred to as forage crops) were grazed by livestock, mowed for hay, or left unharvested.

The climate of the area is characterized by a mean annual precipitation of 34 inches and a mean annual temperature of 51°F. (Page, 1949: 138). Annual snowfall averages about 19 inches (Page, 1949: 147), but undrifted snow seldom exceeds 6 inches in depth at any time and rarely remains unthawed for more than a few days.

The soils of the area, predominantly silt-loams, are highly productive and are tile drained.

Less than 1 per cent of Ford County, in which most of the Sibley area is located, consisted of woodlands (King and Winters, 1952:21). Most of the small amount of woody cover on the area was confined to roadsides, fencerows, small woodlots, and farmsteads and was distributed in the form of solitary trees or shrubs, small groups of individuals, or single-row hedges. Only 6.3 per cent of the roadsides at Sibley were characterized by adjacent woody cover in 1957.

Common trees found on the Sibley area included osage orange (*Maclura pomifera*), American elm (*Ulmus americana*), hackberry (*Celtis occidentalis*), white ash (*Fraxinus americana*), sugar maple (*Acer saccharum*), walnut (*Juglans nigra*), honey locust (*Gleditsia tricanthos*), mulberry (*Morus rubra*), hawthorn (*Crataegus* spp.), wild black cherry (*Prunus serotina*), and wild plum (*Prunus americana*). Common shrubs included smooth sumac (*Rhus glabra*), prairie rose (*Rosa carolina*), multiflora rose (*Rosa multiflora*), and wild grape (*Vitis* spp.). Multiflora rose is a hedgerow plant exclusively; osage orange is commonly found in, but not confined to hedgerows.

Aerial counts of pheasants on the Sibley area revealed 62, 78, and 87 birds per square mile in late winter of 1957, 1958, and 1959, respectively.

METHODS

The association of pheasants with available tracts of woody and herbaceous cover was measured during January-February (winter) of 1958, April-May (spring) of 1957 and 1958, and August (summer) of 1957, 1958, and 1959. These surveys coincided with wintering, nesting, and brooding events in the annual cycle of pheasant populations. During the winter and spring surveys, pheasants were recorded from along 14 roadside-transect routes (totaling about 80 miles) which were cruised at 20 mph by observer (s) in a vehicle. Seven routes were on a north-south axis, seven on an east-west axis. The order in which routes were cruised, and starting point for each, were selected randomly; the routes were cruised at times encompassing all daylight hours. All routes were driven one or more times during each winter and spring survey. During the August surveys, pheasants (including chicks) were recorded from along two 40-mile transect routes cruised weekly (totaling 320 miles annually); these August surveys were begun at sunrise and were completed between 3 and 4 hours later.

Only those pheasants observed within the road rights-of-way were counted. Plowed ground or the type of herbaceous vegetation nearest each pheasant, or group of pheasants, observed was recorded, i.e. an individual or group of pheasants was "associated" with that particular vegetative type both temporally and spatially. Pheasants were arbitrarily recorded as being associated with woody vegetation if they were observed within 100 yards of woody cover. This type of survey best measured the association of pheasants with cover used for loafing during daylight, and also suggested associations with cover used for feeding or roosting.

The herbaceous vegetation adjacent to roadsides on the 37-square-mile Sibley area was mapped during January-February, April-May, and August by driving all public roads (about 80 miles) and recording the types and amounts of cover adjoining each side of the road rights-of-way on aerial-mosaic photographs. (The entire area was aerially photographed annually.) Cover was recorded along about 124 miles of roadside during each seasonal survey, but was not recorded along the exterior sides (about 36 miles) of roads bounding the study area. The percentage of the total linear miles comprised of each type of herbaceous cover was computed from the aerial photographs. In this paper, the term "herbaceous cover" will refer primarily to cultivated crops.

In spring, forage crops were separated by gross examination into three categories based on height of vegetation: short, less than 10 inches; medium, 11 to 30 inches; and tall, more than 30 inches. Height of the cover was affected by species composition and grazing by livestock.

Woody cover was measured differently from herbaceous cover. The crown diameter of each woody plant occurring singly and the length of each group or hedge of woody plants, lying parallel to and within 100 yards of road centers, was measured to ascertain the amount (in miles) of woody cover adjacent to roadsides. If a strip of woody cover adjacent to the road was less than 100 feet wide, both the woody and the herbaceous cover adjoining the roadside were measured separately.

Woody cover was grouped, arbitrarily, into four categories: trees, small trees-shrubs, osage orange, and multiflora rose. *Trees* included all trees (except osage orange) that exceeded a height of 15 feet. *Small trees-shrubs* included all shrubs and all trees less than 15 feet in height. *Osage orange* included all trees of this species, whether growing singly, in clumps, or in hedgerows. *Multiflora rose* was found only in hedgerows. Eradication of woody vegetation between 1957 and 1959 totaled 8 per cent.

Data on the distribution of pheasants with respect to different types of available cover were tested for significant variations by Chi-square methods of analysis.

ASSOCIATIONS OF PHEASANTS WITH WOODY COVER

Pheasants and Woody Cover in Winter, Spring, and Summer

The association of pheasants with woody cover (Table 1) varied significantly among the six survey periods ($X^2 = 656.5$; d.f. $= 5$; $P < 0.001$). Also, the association of pheasants with woody cover was significantly different during winter, spring, and summer ($X^2 = 118.4$; d.f. $= 2$; $p < 0.001$); generally, pheasants were associated with woody cover most frequently in winter, and least in summer.

Pheasants may use woody cover as loafing sites in winter because it affords them protection from adverse weather, even though winter storms in east-central Illinois are seldom so severe as to cause direct losses of pheasants (Robertson, 1958:19). Lyon (1959:287-288) reported that, in Colorado, pheasants deserted deciduous plantings

TABLE 1. DISTRIBUTION OF PHEASANTS WITH RESPECT TO WOODY VEGETATION, SIBLEY AREA, 1957–59[1].

Date	Near (Within 100 Yards) Woody Cover		Not Near Woody Cover		Total Number of Pheasants
	Number	Per Cent	Number	Per Cent	
WINTER					
January–February, 1958	240	69.6	105	30.4	345
Subtotal	240	69.6	105	30.4	345
SPRING					
April–May, 1957	104	35.5	189	64.5	293
April–May, 1958	100	71.0	41	29.1	141
Subtotal	204	47.0	230	53.0	434
SUMMER[2]					
August, 1957	627	67.1	307	32.9	934
August, 1958	183	25.1	546	74.9	729
August, 1959	126	17.5	594	82.5	720
Subtotal	936	39.3	1,447	60.7	2,383
Total	1,380	43.6	1,782	56.4	3,162

[1] This table presents the total number of pheasants recorded during this study; totals in some other tables are less than shown here because some pheasants were not recorded to specific vegetative types.
[2] All counts in August included pheasant chicks.

(windbreaks) of woody cover (often used for roosting) during periods of high winds and heavy snowfall. Perhaps the association of pheasants with woody cover in winter is related to "preference" or convenience rather than to necessity.

The association with woody cover that pheasants evinced during August of 1957, 1958, and 1959 (Table 1), was also significantly variable ($X^2 = 508.8$; d.f. $= 2$; $p < 0.001$). In August, 1957, 67.1 per cent of all pheasants observed were within 100 yards of woody cover; comparable associations with woody cover in August, 1958 and 1959, were 25.1 and 17.5 per cent, respectively. Although the extremely variable association with woody cover by pheasants during August could not be readily explained, a superficial relationship between the proportionate association of pheasants with woody cover and monthly rainfall did exist. Rainfall in August totaled 2.95, 3.63, and 5.03 inches in 1957, 1958, and 1959, respectively; monthly rainfall during August averages 3.18 inches (U. S. Dept. Commerce, Weather Bureau, 1957-59). These data, although inconclusive, suggested that, in August, pheasants were associated with woody cover to a lesser degree as general moisture conditions increased.

Also, during August of 1957 and 1958 (but not 1959), maximum temperatures were recorded weekly at ground level at sites shaded by woody cover and at sites (generally in very short grass) exposed to the sun. In 1957, maximum temperatures during August averaged 85.8°F. at shaded sites and 131.5°F. at exposed sites, a mean difference of 45.7°F. In August, 1958, mean maximum temperatures were 91.5°F. and 116.8°F. for shaded and exposed sites, respectively, a difference of 25.3°F. The mean climatic temperatures for the Sibley area during August averaged 73.4°F. in 1957 and 72.7°F. in 1958 (U. S. Dept. Commerce, Weather Bureau, 1957-58). The disproportionately high association of pheasants with woody cover during August, 1957 (Table 1), may have resulted from the cooler temperatures afforded by the shade of the woody vegetation. In August, 1958, when both the temperatures at exposed sites as well as the differential temperatures between exposed and shaded sites were less than in 1957, pheasants were less frequently associated with woody cover. The true association of pheasants with woody cover in August was partially masked by the fact that the temperature differential between shaded and exposed sites was undoubtedly greatest during midday whereas the counts of pheasants in August were restricted to early morning.

However, pheasants seemingly exhibited a greater degree of association with woody cover under the warmer and drier conditions of August, 1957, than under the cooler and moister conditions of August, 1958. The cool and moist microhabitat (shade) offered by woody cover during the brooding period of August is possibly more important to the survival of pheasants than the protection offered by woody cover during winter.

Pheasants and Different Kinds of Woody Cover

The association of pheasants with the various types of woody vegetation (Table 2) was significantly different in January-February ($X^2 = 78.7$; d.f. $= 3$; $p < 0.001$), April-May ($X^2 = 42.7$; d.f. $= 3$; $p < 0.001$), and August ($X^2 = 33.8$; d.f. $= 3$; $p < 0.001$). Proportionately more pheasants were associated with small trees-shrubs than with the other types of woody cover during winter, spring and summer; osage orange ranked second during spring and summer, and trees, second during winter. Few pheasants were observed near multiflora rose in any season. Two reasons might explain why pheasants were strongly

TABLE 2. ASSOCIATION OF PHEASANTS WITH DIFFERENT TYPES OF WOODY COVER ON THE SIBLEY AREA, 1957–59.

Category of Woody Cover	Miles of Cover Type		Pheasants Observed: Jan.-Feb., 1958		Pheasants Observed: Apr.-May, 1957–58		Pheasants Observed: Aug. 1957–59[1]	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Trees	4.9	50.5	91	45.1	43	28.6	463	49.5
Small Trees-Shrubs	1.0	10.3	58	28.7	30	20.0	128	13.7
Osage Orange	3.3	34.0	52	25.7	76	50.7	331	35.3
Multiflora Rose	0.5	5.2	1	0.5	1	0.7	14	1.5
Total	9.7	100.0	202	100.0	150	100.0	936	100.0

[1] Includes chicks

TABLE 3. ASSOCIATION OF PHEASANTS WITH PLOWED LAND AND DIFFERENT TYPES OF HERBACEOUS COVER ON THE SIBLEY AREA DURING JANUARY–FEBRUARY, 1958.

Cover Type	Miles of Cover Type		Pheasants Observed		Relative Use Index: Birds Per Linear Unit of Cover Type[1]
	Number	Per Cent	Number	Per Cent	
Forage Crops	18.1	14.4	26	12.9	1.4
Corn Stubble	49.7	39.4	61	30.2	1.2
Soybean Stubble	13.0	10.3	6	3.0	0.5
Oats Stubble	21.7	17.2	42	20.8	1.9
Plowed Land	23.5	18.7	67	33.1	2.9
Total	126.0	100.1	202	100.0	1.6

[1] Represents relative number of pheasants per linear unit of cover (along roadsides) as derived from unadjusted number of pheasants per mile of cover type.

associated with small trees-shrubs: (1) scattered small trees and shrubs provided a more spatially distributed type of cover than did the more confined spatial distribution of osage orange or multiflora hedges, and (2) the more diffused and non-uniform growth of small trees and shrubs might have provided more suitable cover than did tall trees or uniform, compact hedgerows.

ASSOCIATIONS OF PHEASANTS WITH HERBACEOUS COVER

Pheasants and Herbaceous Cover in Winter

The association of pheasants with plowed land and different types of herbaceous cover in winter (Table 3) was significantly variable ($X^2 = 49.0$; d.f. $= 4$; $p < 0.001$). A disproportionately small number of pheasants was associated with soybean stubble (0.5 birds per unit of cover) and a disproportionately large number of birds with plowed land (2.9 birds per unit of cover). The association of pheasants with forage crops, corn stubble, and oats stubble was intermediate between that of plowed land and soybean stubble.

The surprisingly high association of pheasants with plowing in winter might be explained on the basis of microhabitat differences. A measurement of mean maximum and minimum temperatures was recorded at ground level in several herbaceous microhabitats (excluding soybean stubble) at Sibley during February and March, 1963. The microhabitat of plowed land was found to be warmer than microhabitats of forage crops and corn stubble, and slightly warmer than that of oats stubble. The lowest mean maximum temperature (39.3°F.) occurred in tall hay, as did the lowest mean difference (24.4°F.) between the maximum-minimum temperatures; this suggested that perhaps forage crops constituted a cold, stable microhabitat. On the other hand, plowing was characterized by the highest mean minimum temperature (15.3°F.); also, the mean maximum temperature of 44.9°F. was higher than that in tall hay. The relatively warmer temperatures of plowed land are a result of increased absorption of solar radiation by the dark surface of plowed land.

Perhaps the high association of pheasants with plowed land in winter was a result of its "warmer" microhabitat.

Pheasants and Herbaceous Cover in Spring

Pheasants were not proportionately associated with the major cover types (Table 4), forage crops, row crops, small grain, and plowing, during spring ($X^2 = 62.0$; d.f. $= 3$; $p < 0.001$). Proportionately more pheasants were associated with forage crops (2.8 birds per unit of cover) than with any other major type of cover; small grains (new seedings of oats) ranked second (2.0 pheasants per unit of cover) to forage crops. Proportionately, pheasants were associated with plowed land considerably less in spring than in winter.

Corn is the top-ranked food consumed by pheasants in Illinois during winter and spring (McCabe *et al.,* 1956:288), whereas soybeans are consumed only infrequently. Waste corn is plentiful in all harvested cornfields. Yet, the assocication of pheasants with corn stubble during winter (Table 3) and spring (Table 4) was less than expected, considering its availability.

The high degree of association of pheasants with forage crops in spring was undoubtedly related to the nesting cycle. An average of 56 per cent of all nests established on a 1,000-acre sample tract on the Sibley study area during 1957-59 were located in forage crops; normally, the establishment of nests reaches the 50-per-cent point by mid- to late May (R. F. Labisky, Illinois Natural History Survey, unpublished data). Thus, the spring (April-May) survey coincided with the period of major establishment of nests, a time when pheas-

TABLE 4. ASSOCIATIONS OF PHEASANTS WITH PLOWED LAND AND DIFFERENT TYPES OF HERBACEOUS COVER ON THE SIBLEY AREA DURING APRIL-MAY, 1957 and 1958.

Cover Type	Miles of Cover Type		Pheasants Observed		Relative Use Index: Birds Per Linear Unit of Cover Type
	Number[1]	Per Cent	Number[1]	Per Cent	
Forage Crops					
Alfalfa-Grass	15.9	6.5	69	15.9	4.3
Red Clover-Grass	11.7	4.8	37	8.5	3.2
Alfalfa-Grass-Red Clover	15.0	6.2	35	8.1	2.3
Sweet Clover Mixtures	3.0	1.2	9	2.1	3.0
Grasses and Weeds	17.1	7.0	27	6.2	1.6
Subtotal	62.7	25.7	177	40.8	2.8
Row Crops[2]					
Corn Stubble	23.5	9.6	25	5.8	1.1
Soybean Stubble	4.4	1.8	3	0.7	0.7
Subtotal	27.9	11.4	28	6.5	1.0
Small Grains[3]	42.1	17.2	84	19.3	2.0
Plowed Land	111.5	45.7	145	33.4	1.3
Total	244.2	100.0	434	100.0	1.8

[1] Sum of observations for 1957 and 1958.
[2] Stubble from previous years' crop.
[3] New seedings of oats, predominantly.

ants would be expected to be associated with forage crops, the major nesting habitat.

The association of pheasants with different types of forage crops (Table 4) was also significantly variable ($X^2 = 23.3$; d.f. $= 4$; $p < 0.001$). Proportionately more pheasants were associated with alfalfa-grass mixtures (4.3 pheasants per unit of cover) than with other types of forage crops. Alfalfa, and brome, its common grass associate, are characterized by earlier phenological growth than are sweet clover, red clover, or timothy. Thus, the alfalfa-grass mixture probably provided better concealment for nests established by pheasants during late April and early May than did other forage-crop species.

The association of pheasants with forage crops of different heights (Table 5) was significantly variable during spring ($X^2 = 21.1$; d.f. $= 2$; $p < 0.001$). Proportionately, pheasants were associated with tall cover (5.0 birds per unit of cover), short cover (3.6 birds per unit of cover), and medium cover (2.0 birds per unit of cover), respectively. The association of pheasants with tall forage crops in early spring was probably a reflection of the superior concealment these crops offered for establishment of nests by hens.

However, the disproportionately high association of pheasants with short cover in spring suggested some complexity in habitat use. Taber (1949:165) stated: "Relatively open ground, where the cock and hens may see one another and where trespassing cocks may be more readily seen, played an important part in the function of the harem." The need by pheasants for "open ground" *per se,* however, appears not to be true. Pheasants were not strongly associated with plowed land in spring (Table 4), which suggests that perhaps the type of open ground may be an important factor affecting its use by pheasants. The unevenness of plowed ground might constitute a deterrent to easy travel by pheasants, particularly when the birds are engaged in courtship. The proportionately greater association of pheasants with forage crops and small grains in spring (Table 4), in contrast to the lesser association with plowing, suggests also that short cover must offer some vegetation and not just be bare ground.

TABLE 5. ASSOCIATIONS OF PHEASANTS WITH FORAGE CROPS OF DIFFERENT HEIGHTS ON THE SIBLEY AREA DURING APRIL-MAY, 1957 AND 1958.

Height of Forage Crop	Miles of Cover Type		Pheasants Observed		Relative Use Index Birds Per Linear: Unit of Cover Type
	Number[1]	Per Cent	Number[1]	Per Cent	
Short	23.0	36.6	82	46.3	3.6
Medium	34.8	55.4	70	39.6	2.0
Tall	5.0	8.0	25	14.1	5.0
Total	62.8	100.0	177	100.0	2.8

[1] Sum of observations for 1957 and 1958.

TABLE 6. ASSOCIATIONS OF PHEASANTS (INCLUDING CHICKS) WITH DIFFERENT TYPES OF HERBACEOUS COVER ON THE SIBLEY AREA DURING AUGUST, 1957–59.

Cover Type	Miles of Cover Type		Pheasants Observed		Relative Use Index: Birds Per Linear Unit of Cover Type
	Number[1]	Per Cent	Number[1]	Per Cent	
Forage Crops					
Alfalfa-Grass	6.0	1.7	16	0.7	2.7
Red Clover-Grass	10.9	3.0	78	3.3	7.2
Alfalfa-Grass-Red Clover	21.5	6.0	232	9.7	10.8
Sweet Clover Mixtures	18.8	5.3	353	14.8	18.8
Grass and Weeds	17.2	4.8	89	3.7	5.2
Subtotal	74.4	20.8[2]	768	32.2	10.3
Row Crops					
Corn	175.4	49.0	829	34.8	4.7
Soybeans	49.2	13.7	310	13.0	6.3
Subtotal	224.6	62.7[2]	1,139	47.8	5.1
Small Grains (Oats)[3]	59.0	16.5[2]	476	20.0	8.0
Total	358.0	100.0	2,383	100.0	6.7

[1] Sum of observations for 1957, 1958, and 1959.
[2] Percentage of total cropland comprised of each major cover type, 1957 through 1959, respectively.
Forage crops: 24.5, 20.0, and 17.5 per cent.
Row crops: 56.1, 63.2, and 69.5 per cent.
Small grains: 19.4, 16.7, and 13.0 per cent.
[3] Predominantly stubble.

ground. The muddiness of ground, which undoubtedly hinders somewhat the travel of pheasants, would be less on ground with short vegetation than on plowed land. Thus, short vegetation could represent an essential habitat type for behavior activities of pheasants during the breeding season.

Pheasants and Herbaceous Cover in Summer

Pheasants were disproportionately associated with forage crops, row crops, and small grains (Table 6) during August ($X^2 = 252.9$; d.f. $= 2$; $p < 0.001$). The greatest proportion of the pheasant population in August is comprised of young pheasants, many of which are still members of individual hen-brood units. In Iowa, Kozicky (1951:90) reported that broods of pheasants were most frequently associated with hayfield vegetation. Thus, the disproportionately high association of pheasants with forage crops and small grains represented the expected use of these cover types as nesting, loafing, and roosting sites. It should not be overlooked, however, that nearly half of all pheasants observed during August, 1957-59, were associated with corn and soybeans (Table 6). This latter point was a reflection of the large proportion of land area planted to row crops annually. Thus, row crops, as well as forage crops and small grains, must be considered an important habitat type for pheasants during the brooding season.

During the summer, the different kinds of forage crops were subjected to various management practices, *i.e.*, grazed by livestock, mowed for hay, or clipped for weed control. Thus, it was difficult to evaluate the relative association of pheasants with the different types of forage crops during August because of the vast differences in vegetative conditions among types. Forage crops, such as alfalfa-grass and red clover-grass, were generally mowed for hay one or more times each summer and, consequently, offered little cover for pheasants during summer. On the other hand, sweet clover mixtures usually produced a poor-quality hay, and so were left undisturbed (or were lightly grazed) throughout the summer. The rate of association of pheasants with different kinds of forage crops in August reflected the proportion of each type that was left undisturbed, as evidenced by the high degree of association with sweet clover.

SUMMARY

The distribution of pheasants with respect to the proportionate availability of different types of woody and herbaceous vegetation was investigated by means of roadside surveys on a 37-square-mile area in the cash-grain belt of east-central Illinois during the winter, spring, and summer of 1957-59.

The degree of association of pheasants with the small amount of woody cover available on the area was variable among seasons; generally, pheasants were associated with woody cover most frequently in winter and least frequently in summer. The association of pheasants with woody cover in summer might be related partially to the microclimate, at ground level, of the woody cover. The number of pheasants observed near woody cover in summer was proportionately greater under warmer and drier weather conditions than under cooler and moister conditions. Possibly, in Illinois, the shade offered by woody cover in summer may be more beneficial to pheasants than the protection from weather that woody cover offers pheasants in winter. Pheasants were associated more with small trees-shrubs than with tall trees or hedgerows of osage orange or multiflora rose.

In winter, proportionately more pheasants were associated with plowed land than with any other major type of herbaceous cover; this may reflect the fact that plowed land exhibited a warmer microclimatic temperature than did any other major cover type. In spring, pheasants were most frequently associated with forage crops, particularly the early growing alfalfa and grass mixtures, which was a reflection of the importance of these crops to nesting by pheasants.

In spring, pheasants were more often associated with tall and short forage crops than with those of medium height. The association of pheasants with tall forage crops probably reflected the superior concealment that these crops provided for establishment of nests. The greater association of pheasants with short forage crops (and small grain seedings) in spring, in contrast to the lesser association of birds with plowed land, suggested that short *vegetative cover,* and not just bare ground, could represent an essential habitat type for behavioral activities of pheasants during the breeding season.

In summer, pheasants exhibited a disproportionately high rate of association with forage crops and small grains, which provided nesting, loafing, and roosting sites. Yet, nearly half of all pheasants observed were associated with corn and soybeans, which reflected the large proportion of the land area planted to these crops annually.

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THE RESTOCKING OF FISHER IN LAKE STATES FORESTS

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INTRODUCTION

An effort to restore the fisher (*Martes pennanti*) to portions of its former range in Northern Wisconsin was initiated by the Wisconsin Conservation Department in 1956 when they entered into an agreement with the New York Conservation Department to exchange bobwhite quail for fisher. A fisher management area was established on the Nicolet National Forest in coooperation with the U. S. Forest Service. In 1961 the program was expanded to include releases of fisher on the Ottawa National Forest in Upper Michigan which lies to the immediate north of the Nicolet.

In addition to the re-establishment of these interesting and valuable furbearers to their former range, the Forest Service is interested in the fisher as an effective predator in controlling porcupines (Cochran 1955). Porcupine populations of sufficient density to cause damage to timber stands occur on both of these national forests.

As interest in the establishment of the fisher grew, the Forest Service became more active in the program by arranging with the Minnesota Department of Conservation to live-trap fisher on the Superior National Forest. Because of this arrangement, more animals became available for release on the Nicolet and permitted the project to be expanded to include releases on the Ottawa National Forest.

From 1956 to 1963, a total of 60 fisher were released on the Nicolet National Forest and from 1961 to 1963, 61 were released on the Ottawa. A total of 121 fisher (78 males and 43 females) has been released on both forests.

Background Information on Fisher

The fisher is believed to have ranged over most of the forested areas of Wisconsin and Michigan (Burt, 1948). By the late 1920's it had become very rare or non-existent in both states. In Wisconsin the species probably vanished sometime between 1900 and 1920 (Hine, 1961). The 1927-28 Biennial Report of the Michigan Department of Conservation stated of the marten and fisher, "They are so nearly exterminated that there appears no chance they will ever come back." The 1933-34 Bienniel Report stated, "It is believed that marten and fisher are practically extinct throughout the State." There had been no authenticated reports of fisher in either Wisconsin or Michigan for almost three decades prior to the first importations in 1956.

Logging and burning of the forests of Michigan and Wisconsin undoubtedly had an adverse effect upon the fisher. Values up to $150 for a fisher pelt during the first three decades of this century made it profitable for the trapper and hunter to pursue a fisher until caught. It is an exceptionally vulnerable animal to trapping and hunting. The combination of these factors contributed to their final extirpation.

The decline in fisher populations occurred over most of its range in the eastern part of the North American Continent. Fortunately extermination was not complete in all parts of its range. In the past two decades the fisher has increased in numbers and extended its range in Ontario (deVos, 1952), the Adirondack Mountain Region of New York (W. J. Hamilton and A. H. Cook, 1955), New Hampshire (G. T. Hamilton, 1957), Maine (Coulter, 1960), and Minnesota (Balser, 1960). The recovery of the habitat, statutory protection, and a drastic decline in the value of fisher pelts have been important factors in the resurgence of the fisher in those areas.

The above authors who reported on the fisher in New York, Maine, and Minnesota noted a concurrent decline in the porcupine populations in those areas where the fisher increased. A decline in the porcupine population, similar to the one noted in the Adirondacks of New York, did not occur in the Catskill Mountains, an area devoid of fisher (D. B. Cook and W. J. Hamilton, 1957). While some observers report the effect of fisher upon the porcupine population, other observers minimize the predator relationship, theorizing that the decline in the porcupine is the result of the same ecological factors that contributed to the rise of the fisher. This project offers opportunities to explore unknown facets of the relations and ecology of both species.

Other Programs to Restock Fisher

The first known attempt to restore fisher was made by Nova Scotia, where, in 1940, the fisher was reported to be "now probably extinct." In 1947 and 1948, a total of 12 ranch produced fishers, six males and six females, were released in the northeast corner of Queens County. In 1955 and 1958 "young" fisher were trapped within 25 miles of this release site and other track observations and fisher sightings have been reported. The chronological order of these notes and reports indicate that the species is reproducing and spreading and that the fisher is now a part of the fauna of Nova Scotia (Benson, 1959).

A fisher restocking program has also been in progress in the Northwest. This program was a cooperative effort involving the Game Departments of Idaho, Montana, and Oregon; the British Columbia Fish and Game Branch; and the U. S. Forest Service. The animals were trapped in British Columbia and first released in Montana in 1959-1960. Releases were made in 1961 in Oregon and planned for 1962 in Idaho (Morse, 1961 and Kebbe, 1961).

FISHER RESTOCKING PROGRAM IN MICHIGAN AND WISCONSIN

Cooperative Aspects

Cooperation of all agencies concerned has been of the highest order and the program has run very smoothly.

The first eighteen fisher released were trapped in New York by personnel of their Conservation Department and shipped to Wisconsin for release. These animals as well as those subsequently received from Minnesota were handled and released on the cooperative fisher management area on the Nicolet National Forest by the Wisconsin Conservation Department District Game Manager with assistance from Nicolet personnel.

When arrangements were made to live-trap fisher on the Superior National Forest, trapping and exportation permits were issued to the U. S. Forest Service by the Minnesota Department of Conservation. Minnesota game wardens and refuge patrolmen did the live-trapping. In all, 103 fisher from Minnesota were released. All transportation costs incurred in the trapping operations on the Superior National Forest were borne by the U. S. Forest Service. Both Minnesota and Forest Service personnel tended the animals while they were awaiting shipment.

The releases on the Ottawa National Forest were handled by the Forest Service under the authority of an importation permit issued by the Michigan Department of Conservation. Biologists from Michigan's Cusino Wildlife Experiment Station have provided the Ottawa advice, assistance, drugs and equipment to handle the animals prior to release. State personnel also helped in selecting release areas and reporting fisher activity.

Live-Trapping Techniques

Live-trapping operations on the Superior National Forest were carried out during the winter months from 1958 to 1963. Generally, the most successful trapping was in March. This is probably because of greater activity brought on by warming weather, settling snow and the ensuing rut.

A knowledge of traditional travelways of fisher aids efficient live-trapping. Bait stations were placed near these travelways. Large pieces of raw meat, usually cut from car-killed deer, were used. A hut of conifer boughs was built over the bait. This protected the bait station from avian scavengers, deep snows, and provided a place of seclusion for the fisher to feed.

When sign indicated a fisher was working the bait regularly, a wire mesh live-trap was placed in the shelter and baited. Commercially made traps of heavy gauge wire, measuring 10 inches wide by 12 inches high and 32 inches in length, with a single trap door entrance, were used.

Traps were tended daily, preferably in the morning. The animal will succumb to exhaustion and exposure if left too long in the trap. Trapped animals were quieted by covering the trap with a tarpaulin. They were transported from the woods to holding boxes in the darkened trap.

Holding and Shipping

The animals were generally held only a few days prior to being shipped. However, it was found that they can be kept for several weeks if properly fed and watered daily, and kept in adequate pens where they are not subjected to much disturbance.

A fisher must be kept and shipped in strong individual containers. Boxes must be metal lined. Those fisher sent from New York were air expressed to Wisconsin. Most of those coming from Minnesota were delivered by truck, although air express from Duluth was used in 1962.

Handling and Release Procedures

When fisher were received, they were marked by placing a numbered metal tag in each ear. The sex was determined, and the animal was weighed and examined for apparent physical condition. The handling of these animals has its hazards. In the interest of safety, Chlordiazepoxide (Libruim, Hoffman-LaRoche) was administered to the fisher that were received on the Ottawa in 1962 and 1963 with satisfactory results. Drugged animals were held two to three days and released after the effects of the drug had dissipated.

All possible factors were considered in selecting release areas. In Wisconsin, Antoon deVos, of the Ontario Department of Lands and Forest, inspected the selected area and stated that the habitat offered good possibilities for the re-establishment of the species (Bradle, 1957). This part of Wisconsin is covered with heavy hardwoods and large coniferous swamps and is within the Pine River watershed. There is very little human habitation in the area. On the Ottawa the factors considered in selecting the release area were the general cover types, the lack of human habitation or activity, including predator trapping, and the distance from the release area in Wisconsin. The predominant cover type in the general area is mixed hardwood-hemlock interspersed with coniferous swamp and pine types. Numerous small lakes are present.

Protection

The fisher is protected by law in both Wisconsin and Michigan. However, they are vulnerable to traps which are baited or scented to take such species as coyote, bobcat, and fox. In Wisconsin, an area of about 40,000 acres was closed from 1956 to 1962 to all trapping except water sets for beaver and otter in season. In 1962 the closure was extended for at least three years, and the area was enlarged to 120,000 acres. Mink and muskrat have also been added to the species which can be taken during trapping season. Funds for the payment of bounties were not appropriated in 1963 and bounties are not now being paid in Wisconsin.

The release area in Michigan is less accessible and it was felt that predator trapping was not too serious a threat to these fisher. However, a substantial number have been trapped. The Ottawa National Forest has proposed to the Michigan Department of Conservation, the closure of two areas totaling 317,000 acres with regulations similar to those in Wisconsin. The Conservation Commission has deferred action on this proposed closure pending the legislative fortunes of an effort to abolish bounty payments. The abolition of bounties would result in the best protection from accidental trapping.

APPRAISAL OF RESULTS

Evidence of Survival

A continuing effort is being made to appraise the survival of stocked fisher. Personnel of both Forests and Conservation Departments and the general public have been requested to be alert in making and reporting observations on evidence of fisher activity. Special efforts to locate sign have been limited to occasional searches for tracks in fresh snow and in establishing a few bait stations for observation.

In Wisconsin, reports on sight observations and tracks have generally increased as additional animals were released from year to year. Although reports of observations in the winter of 1963 were less common, reports in the present winter of 1964 are again encouraging.

Recovery records to date include 11 animals as follows: Six fisher have been found dead in steel traps; one male kit was found apparently abandoned; four fisher were reported released alive by trappers from their trap sets.

In Michigan there have also been continuous reports of fisher activity since the first release in 1961. After checking on about 150 reports, 89 have been classed as authentic, either by the validity of the observer's description or because the observer is a person that knows the fisher and fisher signs. Of these 89 reliable reports: Eighteen have been sight observations; 28 have been track observations; 16 have been fisher signs found at the remains of dead porcupines; 15 fisher are known to have been found dead in steel traps; three have been killed on roads; one was shot; one was found dead of an unknown cause; and seven have been found in steel traps and were reported to have been released alive.

Ten bait stations were scattered through an area within six miles of some of the release points on the Ottawa in January 1963. Periodic checks of these stations were made through March and six of them had been visited, with varying frequencies, by fisher.

Evidence of Reproduction

Of the 27 fisher that have been recovered in both Michigan and Wisconsin, 10 had no tags and showed no indication of ever having been tagged. The first recovery of an untagged animal was a large male that was killed on U. S. Highway 45 just north of the Michigan-Wisconsin line in May 1960. Included in the 10 untagged recoveries are the male kit that was found in the Wisconsin fisher area in May 1962 and a female kit that was found dead on a road in June 1962 near the 1961 release area in Michigan. Some of the trapped females have been lactating.

Evidence to date of reproduction is circumstantial, since all untagged animals that have been captured could have been the progeny of females that were pregnant when released.

Movements

Twenty-one of the recovered animals were within 30 miles of where they were released or within 30 miles of a release point in the case of untagged animals. The other six have been tagged males that were recovered anywhere from 40 to 65 miles from the point of release. One of these males was caught in a trap near a release site on the Ottawa, but the ear tag showed it had been released 40 miles to the south in Wisconsin the year before. One fisher was trapped within a month, 10 miles from where it had been released. The longest elapsed time from release to recovery has been 31 months. This animal was found dead 21 miles from where it was released.

Approximately 55 percent of the other observations of fisher activity have been within 10 miles of a release point and over 90 per cent have been within 30 miles. A few reliable observations have been reported on the Menominee Indian Reservation some 60 miles south of the release area in Wisconsin. A few, but continuous, reports indicate that a small number have moved to an area 40 to 60 miles northwest of the release area on the Ottawa and another small number moved 50 to 70 miles to the east.

Evidence of Predation on Porcupines

Evidence of predation on porcupines is difficult to find and substantiate. In Michigan, however, the remains of six porcupines were found in one day on an area of about 100 acres. There were fisher tracks around each kill and throughout the area. The remains of 10 other porcupines have been found where tracks or other signs were present. The remains of six other porcupine have been found where there was no sign present, but near areas where previous or subsequent fisher observations were reported. Many of the fisher that have been turned in by trappers have had quills inbedded in their carcasses.

CONCLUSION

The fisher was once considered to be a vanishing species in many areas of its former range, but in the past two decades it has made a remarkable resurgence in areas where remnant populations had persisted. Since it obviously did become extinct in that portion of its former range in Michigan and Wisconsin, it was felt that restoration would be possible by transplanting live-trapped fisher in suitable areas of these two states. A total of 121 fisher was released on the Nicolet and Ottawa National Forests through the cooperative efforts of the New York, Minnesota, Wisconsin, and Michigan Conservation Departments and the U. S. Forest Service.

Observations indicate that these fisher have survived and the majority of the animals have remained within 30 miles of the release areas. It is probable, although the evidence is circumstantial, that they are reproducing. Evidence of fisher predations on porcupines is encouraging, but no effort has been made to evaluate the effect the fisher may have on the porcupine population.

It would be premature to say that these releases will be successful in establishing a fisher population. Further stocking is not planned, pending further study of the results. Although it appears that these animals have survived, reproduced, and that the habitat is suitable, there is still the question of whether they can be restored, or exist where there is unrestricted predator trapping and a bounty system. It is felt now that this is where the success or failure of this program is hinged.

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DISCUSSION

MR. RALPH DIMMICK (University of Wyoming): I would like to ask the author if there is any evidence of cases where established fisher population have controlled porcupine population?

MR. IRVINE: As I pointed out, there have been reports of porcupine population declines in Maine, New York and Minnesota. Hamilton's report on the fisher in New York strongly indicates that the fisher has been responsible for reducing this population. There has been no recent study of it. It has all been more or less a casual observation.

MR. G. W. DAVIS (Vermont): For several years, we have had a similar program and while we have not had too much factual data to substantiate it, I think there is real evidence to show that there has been a marked reduction of porcupine damage, particularly to sugar maples in the area where fishers have been released.

There has also been a tremendous increase in fisher population in Southeastern New Hampshire, down on the extensive 18-mile coastline area where, in a 30-day period, one man trapped 43 fishers. It is one of the most unlikely places you would expect an animal of this type to roam. This may be because it is the center of a rather extensive poultry industry.

I was wondering what the average weight of your animals was.

MR. IRVINE: Well, the adult males ran between 10 and 12 pounds; the adult females ran about 5 pounds or a little over.

MR. DAVIS: That is about comparable to what we have in Maine. The largest one we had was a male that came from New York, which weighed 18 pounds.

MR. S. SHEMNITZ (Maine): Do you have any information on the feeding habits of fishers other than on porcupine and particularly in relation to predation on small deer?

MR. IRVINE: In Minnesota, they have studied some of the food habits up there. They have found there has been a rather striking decline in porcupine population but even with this low porcupine population, they found, I think, it ran second with the snowshoe hare, the latter ranking a high first.

MR. DIMMICK (University of Wyoming): Did the fishers show a corresponding decline with porcupine population falls?

MR. IRVINE: No, it has not declined in any way. Just before coming down here, I received a note that indicated that even though we have been live trapping up there and whatnot, that the population is still increasing and the range is still being extended in Minnesota. They had 185 confiscations of fisher from trappers last year.

MR. ERICKSON (Alaska): Has any attempt been made to measure porcupine abundance, such as the effect of possible fisher predation as a control mechanism, if it can truly be measured?

MR. IRVINE: We have a fairly good idea of the population. We have been working with this several years now on the Ottawa and we feel that our population on what I call the winter porcupine range runs about one oprcupine to 10 to 12 acres. This is mostly in the northern hardwood-pine types.

DR. E. L. CHEATHAM (New York): I thought this might be an appropriate place to inform the audience on the conflicts of interest we have in New York on the management of the fisher. It is rather interesting to try to balance the various interests in fisher population between the snowshoe hare hunters, who want us to just trap the devil out of the fisher, the interests of the forest industry to remove all trappings from the fisher and give it 100 per cent production and the interest of the forest industry in the Catskills for trapping fisher out of the Adirondacks and transplanting them to the Catskill Forest in the interest of controlling porcupines.

Now, we frankly do not want to become involved in a trapping and transplanting program and extending of range of fisher down into the Catskills because we know that we are going to have one heck of a public relations problem from hunters who are interested in their grouse and in their rabbit hunting, etc., because the fisher is a very efficient predator. We are not convinced by the evidence, because we do not have suffcient critical evidence, that the fisher actually is the solution to the control of porcupines damage on forestry. He is a very efficient little predator and takes his food where he finds it. We like him where he is and we do not want to get too much involved in all this interest in deciding what to do with him, at least any more than we are doing now.

TECHNICAL SESSION

Tuesday Morning—March 10

Chairman: Russell T. Norris
Assistant Regional Director, Bureau of Commercial Fisheries, Gloucester, Massachusetts

Discussion Leader: William J. Hargis, Jr.
Director, Virginia Institute of Marine Science, Gloucester Point, Virginia

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COASTAL AND MARINE RESOURCES

HUNGER, MAN, AND THE SEAS

Donald G. Snyder
Bureau of Commercial Fisheries, Technological Laboratory, College Park, Md.

A world in which hunger abounds can have little hope for enduring peace. In the following presentation, we consider the problem of hunger, its relation to man, and then what the seas promise toward its solution.

Hunger

Hunger means different things to different people. The term is used to describe conditions ranging from acute, extreme starvation to the real, or imagined, "hidden hunger" concepts of the TV commercials. But to two billion people in the world today, hunger clearly means chronic undernourishment—chronic malnutrition—resulting not only from a lack of food but also from a lack of food of good quality.

To a segment of this majority of the people in the world, the consequences of hunger may be simply a lack of vigor. But to others, it may mean death to their loved ones—especially young children. Between these extremes of actual starvation and of undernutrition lies poor health, physical weakness, lack of ability for sustained mental effort, and reduced initiative.

By and large, the dietary nutrient factor most lacking in deficient diets is good-quality protein. Protein malnutrition is primarily caused by an inadequate consumption of animal protein that is needed to balance and complete diets containing preponderantly protein from vegetables and cereals. The world's total annual deficit of animal protein is many billions of pounds. Availability and cost of animal protein presently limits adequate consumption of this important nutrient only to the more prosperous peoples of the world.

Other kinds of malnutrition may also be noted. Shortages of calories are quite serious in certain areas. Some areas may also lack adequate levels of vitamins and minerals. Goiter, anemias, rickets and pellagra are still a scourge among some peoples, but the public health menace of these maladies has declined considerably in recent times, owing in large part to our better understanding fo their causes.

Protein malnutrition occurs principally in the so-called developing nations—that is, the poorer, less industrialized countries. The condition is prevalent, however, wherever starchy foods comprise the bulk of the diet. Thus, Asia, Africa, and Latin America presently are the critically affected areas of the world. It is in these areas that most of the two billion hungry people reside. It is in these areas—where the total protein supply is inadequate, particularly the supply of animal protein—that nearly 60 percent of the people eat less than one-half ounce of animal protein daily.

The industrialized nations, however, are not entirely free of this problem either. Wherever incomes are low, some degree of protein malnutrition may be likely, although clinical manifestations of inadequate protein consumption are often difficult to demonstrate.

Sadly enough, wherever notable protein malnutrition exists, the most vulnerable group in the population is young children. In young children, the beneficial effects of animal protein supplementation are most dramatic and can easily be clinically demonstrated, which is not always the case with adults. Kwashiorkor, a disease among children resulting from severe protein malnutrition, is characterized by retarded growth and maturation, apathy, anoxia, diarrhea, vomiting, skin lesions, desquamation, edema, and heavy mortality. These symptoms dramatically disappear when sufficient animal protein is judiciously added to the diet.

The causes of protein malnutrition are complex and interrelated, but poverty seems to be the overriding factor. Even, however, if each member of this planet were prosperous and the competition for good food were equitable, we should still witness hunger resulting from inadequate food supplies, technological limitations, social customs, education and training, and infections. Food and technological limitations are among the factors of vital concern in malnutrition. Other causes of malnutrition supposedly can be overcome in due time and with reasonable action.

Preventing malnutrition may appear simply to be a case of general improvement of the economic status of all peoples of all nations. Like the cause, however, the prevention is not purely economic. One notable difficulty is that in exploding populations, no major new food source combined with the technology necessary to exploit it has been developed.

MAN

The world population doubled during the last 100 years to its present number of 2.9 billion people. Based on present trends, the world population will again more than double in the next 40 years. By the year 2000, Asia, Africa, and Latin America alone probably will have had an increase in numbers equal to the total population of the world today. Considering the problem of hunger that is presently with us, this rate of growth forbodes serious nutritional problems in the future. The Food and Agriculture Organization of the United Nations estimates that of the nutritionally adequate food annually required properly to meet the present need of the world population, only about one-half is now available. The deficit that will develop in the years to come is frightening to envisage.

Unfortunately, malnutrition will not correct itself nor will complete dependence on agriculture accomplish the task. Land resources for crops and animal grazing are not inexhaustible. The total land surface on our globe is 33½ billion acres, and of this total, only 4 billion acres are available as potential crop land—4/5 of which is already under cultivation. If the available, remaining uncultivated land of the world were put into production, the total acreage would supply at best only enough food for the peoples on earth today.

Technological problems are coupled with these agricultural limitations. Problems of food storage and distribution, preservation, control of pests and the like, prevent man from consuming much of the food that he produces. (It is estimated, for example, that one man in every four in middle Africa works to feed pests.) Furthermore, man must consume his food before it spoils, but unfortunately, animal proteins spoil rapidly. We thus face a challenge of alarming proprtions that requires immediate action.

THE SEAS

Although there is not complete agreement, marine biologists estimate that our seas could annually sustain a world catch of 400 to 500 billion pounds of fish. Tragically, about 80 percent of this potential supply is now going to waste. This is true despite the fact that nearly every inhabited coastal area has some sort of fishing activity—a very real potential for supplying critically needed sources of animal protein.

Systematic effort to farm the seas has lagged far behind land effort. Yet the seas, today a vast reservoir of naturally producing animal protein, might with pisciculture techniques provide us with more protein than we can presently estimate.

The nutritive value of fish has been recognized since earliest times. Utilization of this food wealth has always been limited, however, owing to its perishable nature. Conventional methods of preservation are costly and frequently are inadequate. The resultant products are often unsuitable for wide distribution, which explains the lack of stimulation for increased exploitation of this marine food resource for hungry peoples. It is in developing nations, unfortunately, that methods of food preservation are most restricted.

The nutrient return of the protein of fish for malnourished peoples can most economically and efficiently be realized if the preserved material is in a concentrated form suitable for dietary supplementation. In this form, small amounts of fish material containing high-quality protein can be added to available indigenous foods containing protein of poor quality. The result is that the quality of the total protein of the mixture of the foods is improved to equal almost that of the quality of the protein of the fish alone. Not only the quality of the protein, but also the total amount of protein consumed by undernourished people is important. Adding small amounts of concentrated fish material to foods containing normally low levels of protein results in an overall increased level of protein intake by the people eating the supplemented food. Furthermore, concentrated material suitable for supplementation is easily incorporated into all types of local foods and assures good distribution among the members of a family. Other factors, of course, such as the ease of packaging, transporting, marketing, and storage favor, in most instances, the manufacture of a fish concentrate suitable for use as a food supplement. These considerations do not rule out, nor should they, the additional use of fish in other forms.

Interrelated with a consideration of manufacturing a protein supplement is the need to remove water and fat from the fish in such a manner that the final product will retain the high nutritive quality of the raw material yet be markedly more stable. Increasing food deficiencies in the world have therefore necessitated the technological development of a satisfactory method of fish preservation and have stimulated efforts to develop a stable, nutritious fish protein concentrate (FPC) suitable for use as a worldwide dietary supplement.

Since FPC is to be primarily used as a protein supplement to the various nutritionally deficient diets eaten by peoples throughout the world, it has to be produced in a manner consistent with good food-handling practices that do not significantly lower the nutritive quality of the material. Since FPC is intended, at least in large part, for low-income groups, it also has to be inexpensive. The final product, for example, should cost about one-fourth the price of an equivalent amount of protein from dry-milk solids. In addition, the initial cost of the equipment used to produce FPC should not be prohibitively expensive, nor should production be costly. And the processing methods used should be relatively simple and safe, yet flexible enough to produce a variety of products suitable for supplementation in the great variety of diets found globally.

We may therefore define FPC, originally called fish flour, as any inexpensive, stable, wholesome product, hygenically prepared from the whole fish or from any of the parts of fish, in which the protein material is more concentrated than it was in the original raw material. As was just indicated, the concentration of protein is accomplished by the use of processing methods that remove most of the water and some or most of the fat. As was also indicated, this concentration process, in turn, ideally affects preservation of the concentrate. Products produced can, and should, range in characteristics from a paste containing a pleasant meaty taste and odor to a dry powder containing no taste or odor. Products can, and should, range in form from chips to dry powders that are soluble in water. The product FPC, of course, is in no way similar to those products that we identify as flour, such as those made from wheat or corn.

Producing concentrated protein from fish is not a new endeavor. The ancient Egyptians possessed the knowledge, which we now have lost, of how to make at least one form of FPC. In the days of the Caesars, the Romans also found how to concentrate fish. They made it into a paste to be used as a condiment. Toward the turn of the last century, personnel of the old Bureau of Fisheries were conducting limited research on a fish protein concentrate. But only during the last 25 years or so have any extensive endeavors, either by us or others, been made. And only during the last several years has the potential of FPC as a universal weapon in the fight against global hunger received any particular attention. But even yet, unfortunately, FPC has not received its full recognition as a weapon in this crucial fight.

The Bureau of Commercial Fisheries, however, recently obtained funds to develop new methods or to improve existing methods of satisfactorily manufacturing FPC suitable for supplementing deficient diets in various parts of the world. As a result of a preliminary global reconnaissance of the FPC problem, which we now have substantially completed, our research is designed to investigate chemical, biological, and physical methods of FPC manufacture. This investigation is being conducted both at a laboratory level and at a model-unit level. Analytical and biological testing procedures have been started to ensure the adequate control of the quality and the safety of the products produced.

Supporting research is being conducted at leading universities and private institutions throughout the country. Under the auspices of the Food and Nutrition Board of the National Academy of Sciences, a committee composed of leading authorities in many disciplines has been formed to provide advisory services. Research areas—such as biology, chemistry, engineering, microbiology, toxicology, economics, and sociology—are represented.

None of the efforts described, however, can end with the production of a satisfactory FPC product of high quality. Thought must also be given to the needs for study of such aspects as (1) the ease of incorporating FPC products into local deficient diets, (2) the acceptability of these FPC supplemented foods, (3) their human feeding value, and (4) the economics involved as a result of supplementation. We therefore now are planning for the very important feasibility studies that will be required in the future if FPC is really to be the weapon we envisage that it can be in the fight against global hunger.

To gain an idea of what a powerful weapon we have at our disposal, we need merely note that if we converted into FPC just the unused fish found in waters adjacent to the United States—fish that could be harvested annually—we would have enough FPC to supplement the deficient diets of one billion people for 30 days at a cost of less than one-half cent per person per day. With such a weapon available, we believe that we face a serious obligation. It is up to us now to meet this obligation by translating our knowledge into action.

DISCUSSION

MR. HOWARD BRADY (Izaak Walton League, Casper, Wyoming): Newspaper accounts try to follow this type of thing, and it appears to me that a few individuals of very powerful influences are dampening the acceptance of this type of thing. Am I right in this conclusion?

DR. SNYDER: If we are to produce a product that is economically within a reasonable price we have to use whole fish. We can not, for instance, use just the fillets of the fish or parts of the fish. The price would go up at least five times.

The Food and Drug Administration has determined that the use of the guts, the heads, the viscera and visceral contents of the fish are esthetically objectionable, and as such they will not permit the sale of FPC from whole fish in this country.

MR. BRADY: Then I think that, as in many other cases, our great problem in a lot of our progress is the factor of sociology and personalities, perhaps, rather than in the scientifics, and I think it is high time that we as scientists really rap that type of negative influence.

DR. SNYDER: Wonderful!

DR. WILLIAM GRAF (San Jose Junior College, San Jose, California): I was very interested in this paper, and the very fine points presented. I would like to point out, however, that I think this type of information actually in the long run does a disservice to our intelligence as human beings.

This is a group of wildlife people largely dedicated to managing our animal population as a balanced population. Yet here we are, presenting a type of solution which will not produce a balanced human population but merely a population that exists. I am not looking forward to my great-grandchildren and their children living on FPC or some other form of fish paste. This is not living the way we look at living, and actually I think that we are doing a disservice to ourselves by suggesting that this is a solution. It merely provides an excuse to procrastinate a little longer as far as a real solution of this hunger that exists.

The hunger exists. I am not against the solution for those people that have that. At the same time I am against any suggestion that this is the final solution, and I hope that this is not what is being suggested by this paper. This is not a solution; it is merely staving off the real solution to this problem.

DR. HARGIS: Of course this is a complicated problem.

I don't know whether the gentleman expected an answer or not. I see that he has left the room. But I think that Dr. Snyder would like to make a comment here.

DR. SNYDER: No, in no way is this an entire solution. But it seems to me that with this magnificient potential available and 2,000,000,000 people starving to death is behooves us to look at all of the aspects of the solution to this problem. I don't know if he is referring to some kind of population control or something like that, but that is certainly not within my purview. I will say this, though, that two billion people will not continue to be denied food without some very serious political consequences. I think any solution that suggests any attack on this problem, suggests a partial solution, should be followed up.

MR. DAVID BROWER (Sierra Club, San Francisco, California): I wanted to back up Dr. Graf in his comments and just make one brief commercial plug for the little thing we have on our handout table outside, which relates to population problems. The title is *How Dense Can People Be?* It fights, I guess, against the self-fulfilling prediction that if we say there will be double the population in forty years, we are by that statement, and by acting upon it and predicating all our programs upon it, almost assuring that this will happen, and I don't think very many people any more think that that is a good prospect.

DR. HARGIS: I would like to comment myself, of course. The theoretical and the ideal situation are what we should work for, but I must comment that even in populations where there are manipulations and manipulation is much easier than in human populations, we are not doing very well in management, so that while I personally wouldn't suggest that this be the long-term approach, I do suggest that practicality has to enter into the problem, and Dr. Snyder's group is one phase in a large machine which we hope will eventually achieve control, but only one phase—one important phase.

MR. ALBERT H. SWARTZ (Bureau of Sport Fisheries and Wildlife, Annandale, Virginia): I would like to make a comment, starting off with an old cliche that man can't live by bread alone.

In 1960 a national survey showed that there were close to 7 million salt water anglers that had 80 million man days of sport and caught nearly three-quarters of a billion pounds of salt water fishes for recreation, and I sure hope that all the fishes in our coastal waterways aren't ground up for fish paste; that a few are left over for recreation.

DR. HARGIS: Mr. Swartz, why did you have to introduce that complicated factor? [Laughter]

DR. SNYDER: As a matter of fact, again economics comes into play, and if we are going to produce a product that is within the price range of people, reasonably we can't go out and fish this kind of fish that aren't schooling, that aren't easily caught in great numbers. I think that the aspect here is to try to get as great a mass of fish as possible, the schooling types of fish that could be caught quickly and easily. I think the biologists figure it at a cost per unit. We are not interested in bluefish that are found schooling off a shoal off of Florida, or something like that.

You know, one angler standing up there catching one fish, that doesn't even seem to me to be the right kind of economics. We are talking about millions and millions and millions of pounds of fish caught easily at little cost.

MR. ROBERT SIMPSON (Moorhead, North Carolina): Very briefly, you are basically referring to the menhaden industry and this sort of thing. I believe this is doing the entire development on this, or am I wrong?

DR. SNYDER: Of course the menhaden industry, I think, is preeminent as a possibility of catching large amounts of fish. They have the technological experience and so forth. Most of our efforts are directed toward industrial type fishes, such as the menhaden.

MR. SIMPSON: Just following that up, we are having a bit of a problem. What the answer is we don't know. But it is with regard to the use of what we call "trash" fish, "trash" fish being any fish that is not considered a food fish, but we have discovered in our particular area that this includes any fish that is small, and we are having quite a problem. We are running surveys, and it is too early to give a definite breakdown on the content, but they are utilizing a large number of food fish in this particular thing, and our area is quite interested in this from a conservation angle.

DR. SNYDER: I am an organic chemist. I know nothing about that.

DR. HARGIS: I might comment that theoretically, as long as the utilization of trash fish would not affect adversely the populations of those species that are involved in the next year, or two or three years, there should be no objection. This, of course, is a point that is difficult to establish.

DR. CLARENCE TARZWELL (R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio): Do you use the fish flavor or do you remove it? Secondly, are you giving any consideration to the handling of your wastes, since you will be handling several billion pounds, perhaps, and their pollutional effects?

DR. SNYDER: First let me answer the second question.

In this process there is no waste outside of the oils that remain. In other words, we envisage that we would use all of the fish. The nutritive quality of the head is just as good as the nutritive quality of the tail, so in the first place there would be no waste outside of the oil, which is of commercial importance today; in fact, pretty much so.

Second, the first question. We can, by altering methods of manufacture, produce (ideally, I am speaking now, because we have yet to do some of this work) any kind of product, any kind of taste, with any kind of form or texture that is indicated for peoples in certain areas. In other words, in some areas people would prefer a bland powder with no taste or odor. We can product that. We can put that into bread, and then of course the bread just doesn't taste like it has been supplemented with anything.

Other people would prefer a very strong, fishy flavor. We can produce that. Other people would prefer a paste with a meaty flavor, a meaty taste, like a bouillon cube, and we can produce that, you see. So take your pick.

Our ultimate goal is to find out what peoples in these developing nations prefer as far as their taste preferences and their flavor profiles area, and then we produce what they would want.

ESTUARINE DESTRUCTION . . . A MONUMENT TO PROGRESS

GEORGE W. ALLEN

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VALUE OF ESTUARIES

Perhaps nowhere else on the known surface of our globe are there found areas that are equal in diversified values as those to be found in the estuaries located wherever the large drainage basin rivers meet the saline waters of the sea.

The value of these areas are in many diverse activities: commercial in the form of furs, fishes and shellfish; recreational in the form of fishing, hunting and boating; and industrial in the form of factory sites with available water transportation and water supply for processing. It has been computed by investigators that in the production of available protein that could eventually be made available to the public, the estuarine areas are the greatest producing areas to be found anywhere.

In addition to the above considerations, these estuaries are the fundamental link in the development of many of our commercial fisheries such as the menhaden and shrimp industry, and the direct environmental factor in the production of oysters and other shellfish. It should also be remembered that many marine fishes either pass through or temporarily reside in these estuaries sometime during their life cycle. Considering this, therefore, many species such as salmon would find a barrier to their complete life cycle should the estuaries either be destroyed by contamination or actual physical elimination.

Humans, by their very nature, appear to settle near the large and important waterways of the world, and many of these waterways are either directly associated with an estuarine area, or are indirectly connected with it as a source of transportation and supply. Whereever there is a large estuary, there is a concentration of human habitation. In North America, the largest estuaries are closely allied with the cenuters of population. The reason is that they are either a source of water for the industrial processes of the area, or they are an outlet to a transportation system using the waterways of the large rivers into the interior, or the unlimited advantage of location by an ocean or deep water navigational channel for local and world distribution of their products.

Where there are estuaries there also are population or industrial centers. This is demonstrated by the Hudson River estuary close by New York City, Delaware Bay with its numerous industrial complexes, Chesapeake Bay with Norfolk, Washington and Baltimore being nearby, the Carolina coasts with Savannah and Charleston, the Gulf coasts with Mobile, New Orleans, Pascagoula, Houston and other industrial areas. There are also the modified estuaries found on the west coast with Los Angeles, San Francisco and the northwestern ports of Seattle and Portland. All of these are closely associated with estuaries of one sort or another and of some size, either large or small depending on the physical characteristics of the coast line.

MEANS AND METHODS OF DESTRUCTION

In considering the problem of estuarine destruction, it must be remembered that the destruction is not the main objective of the activities associated with this problem, but rather is a secondary effect of the development involved. It is not believed that any of the agencies involved would deliberately set about to destroy these vital areas, but rather do not consider the results of such actions in their over-all planning.

The problem reduced to its simplest form is the continued population growth and its tendency to concentrate around marine areas. With the continued expansion of our population comes an increased demand for manufactured products. This in turn requires more and more industrial sites throughout the nation. Where there is an expansion of industry there is also an expansion or problems involved in the housing of the workers and indirectly the consumers of the manufactured products. With the tendency of urban development to do away with the crowded city-type programs and move towards ranch style suburbia, much of this housing is being located along rivers, bays and canals. This affords everyone with a "water front home" in areas where such developments are possible. This is of course to be found in our estuarine areas. In addition to the above problems, we also have the ridiculous situation where there is a drainage of our coastal marshes in order that more agricultural areas can be developed to grow crops and to pasture cattle that are already in surplus. All of the above agricultural projects are taking place while the soil bank is paying the American farmer an exorbitant sum to take already prime agriculture areas out of production and requiring him to grow trees and weeds.

There are three agencies or types of agencies that are responsible for the majority of the estuarine destruction that is taking place today: the U. S. Government and state agencies, the industrial development agencies, and last but certainly not least, private enterprise.

The Federal Government and its agencies associated with such problems are the U.S. Army Engineers, the Soil Conservation Service and the Federal Bureau of Roads. There are other minor agencies involved but the above are the so-called big three with which we must deal.

The Army Engineers' biggest projects that are thrown in the lap of the estuarine conservationist are their navigational channels through the marsh areas leading from the ports to the sea. One of the biggest of such projects is the Mississippi-Gulf Outlet Canal from New Orleans to the Gulf of Mexico. The potential damage that was involved in this project was not so much from the channel itself, but rather the tremendous volume of mud that would be removed from the channel and the spoil banks that would be created as a result. To offset this damage there was developed a series of spoil impoundments into which the soft mud was pumped as it was removed from the channel bed. These impoundments had their own water control structures so designed that as the mud was pumped into one side, the sediment and other material settled to the bottom and the relatively clear water was released through the control structure and out into the marshland. These impoundments were placed and developed in such a manner that the transverse pattern of water flow through the marshland running east and west and the normal interchange of water through natural currents was not disturbed any more than necessary. This system of impoundments was an extremely high added expense, but the Army Engineers were not too disturbed if it meant that the natural condition of the surrounding marshland and the production of its estuarine resources would not be destroyed. It must be remembered that this system was developed after many coordinated meetings with the Engineers, the Louisiana Conservation Agencies and the U.S. Fish and Wildlife Service. The cost of biological and habitat research alone exceeded $200,000. This was paid for by the Engineers as a part of the total project cost. While this project is outstanding in its engineering features, to the conservationists it is even more outstanding as a demonstration of what can be accomplished by organized coperation between agencies from different branches of government and state levels.

The second federal group from which the estuarine areas have at times received rather severe treatment, and one which will continue to be interested in the availability of the marshlands for their projects, is the Soil Conservation Service of the U.S. Department of Argriculture. The reclamation of so-called worthless lowlands for their projects constitute a continual danger to our wetlands. This has been seen in the programs of this agency that have affected our marshlands in the north with relation to the breeding grounds of our waterfowl. At present this agency is considering the reclamation by dyking and other dewatering methods, thousands of acres of Louisiana marshlands in the western portion of that state. This will completely eliminate the major portion of this area as an estuarine area, and will turn it into an area for the grazing of cattle. While this land will produce grazing conditions that would be suitable for the expansion of the livestock program, there are other areas that would be less expensive to develop, and would be closer to market and rail facilities.

This large program should be closely associated with the soil bank program that through the very same agency has just finished taking thousands of already prime grazing areas out of production.

This program is still on the drawing board or in the planning stage, but it is definitely a planned program and the Soil Conservation Service has every intention of going through with this program at the present time. I do not see how any conservationist that has any interest in such an area, or any federal agency that has any concept of the value of our estuarine areas, can go along with such a program of wholesale destruction. I will admit that I have not gone into this particular program to any great detail, but on the surface this project appears to be a very "white elephant" indeed. There must be some great demand for cattle of which I am not aware.

When some of the agencies responsible for such plans are questioned about the justification for such programs, the usual answer that one received is that local interest is strongly in favor of such programs and is demanding that such action be taken. Those of us familiar with some of these programs realize however, that much of the initial interest at the local level has been generated by the agency itself, and not by the initial demands of the communities involved. Everyone, including myself, likes to feel that they are getting something for nothing. If the costs of such a program are spread thin enough through taxation of dry-land farmer in Arizona who could use some irrigation help, and a snowed-in rancher in Montana who could use some emergency winter feed, the cost to the individual in the development of dyked and pumped pastureland in Louisiana is not too great. Such projects as these should be looked at with a critical and jaundiced eye by the conservationists whenever they appear on the program of any agency, be it federal, state or private.

The third federal agency from which the estuarine areas are getting especial attention is the Bureau of Public Roads. This is not something new, but the expansion of this agency by the enlargement of the interstate throughways has brought some of these problems to the front at a greater rate than before.

Fortunately, such programs have been most cooperative with the various conservation agencies involved, and every effort is being made to keep the damage to the estuarine areas involved to a minimum. It should be strongly urged however, that this problem cannot always be left to the Bureau of Public Roads to solve by themselves. It should be remembered that this agency, as well as the State Highway Departments involved must get every mile of super highway as cheaply as possible. At times this justifiable desire might cause these agencies to overlook or ignore the estuarine damage that they might incur. State, federal and local conservation groups should be kept aware of such impending developments, and should keep the highway interests informed of this awareness. The Bureau of Roads and the State Highway Departments have never shown any great reluctance to go into expensive construction and alteration of routes if such construction and alterations can be justified. It is our duty as protectors of our natural resources and the environments in which they exist to keep these highway agencies informed of the value and the desires to keep the natural resources in balance with these developments insofar as possible.

Mobile Bay is one of the few remaining undeveloped estuaries on the Gulf Coast. It has only recently been threatened by the installation of two interstate routes through the area. As a result of the efforts of all agencies involved, there has been unified accord on the possible locations in relationship to the type of bridging, the routes for final selection, and the attempts on the parts of all parties to come to a final understanding that will bring about the least damage to the estuary involved. The important thing to keep in mind is the fact that if such a coordinated program had not been undertaken, there would have been irreparable and lasting damage done to the estuarine resources involved. I might also add, that while the technicians worked out the details and the justifications for additional costs involved in the construction of the least damaging of the routes and methods of construction, the attitude of our Governor and our state highway director, together with the cooperative efforts of the Bureau of Roads officials, made the final cooperative decision possible. This is a good example of what can be done with a public aware of the problem and willing to take an active part in the programming of the project, a state conservation agency dedicated to the preservation of the marshland, and the officials of the highway department being interested enough to consider our problem. What the results would have been had any one of these groups failed in its responsibility is difficult to determine, and fortunately we have not had to meet that problem.

The second major group which have shown continued interest in our waterfront areas are the industrial expansion groups. While the effects of the actual building inself is generally not too serious, the secondary effect of industrial pollution in the form of bacterial and chemical pollutants resulting from the processes involved may well destroy more actual estuarine production than many physical changes.

The entire time allocated for this session could be used for the discussion and condemnation of pollution. It is diffcult to walk away from this subject without making at least one comment. No one realized that we in Alabama have at times the largest settling basin in the state in the form of Mobile Bay. Only by continual monitoring of these waters are we able to maintain our oyster production. As of this date we have had no record of any of our production bringing about any mortality to the consumers. Each year however, we must exercise greater surveillance of our areas.

The effect of the many navigational locks on the river system draining into Mobile Bay is especially felt during periods of minimum rainfall. This low rainfall requires that all water possible must be held above these navigational control structures to allow river traffic to continue. At the lower end of the river system, below these dams, the river discharge is smaller than normal. As a result the pollutant materials are not continually being flushed into the bay area in low concentration so that dilution is a controlling factor. This allows the concentration of these pollutants to build up to severely abnormal concentration, and when the heavy winter rains do come and the navigation structures are spilling to capacity, this built up residue of pollution comes into the bay area in one large dose, and normal dilution has little if any effect. When this happens, our oyster industry shuts down its production except for those areas not in the path of the pollutant material.

This problem could be solved by requiring a specific minimum flow through the navigation structures which would keep the downstream portion moving enough to prevent concentration of contaminants.

Another industrial problem is brought about where navigational channels are cut through swamplands to reach production centers. The introduction of such channels brings about an intrusion of salt water through the channel into areas normally not exposed to high salinity. This change in salinity brings about a change in habitat and ecology. As a severe example, last year we found commercial size shrimp in the Jackson Lock and Dam on the Tombigbee River in Alabama. This was a distance of 117 miles upstream from Mobile Bay. Another example is the building of the Mississippi River-Gulf Outlet project. This project has introduced a salt wedge into Lake

Pontchartrain, which in turn has developed a problem for the New Orleans Water Board. They now have to combat oysters growing on their pumps and plugging their pipe lines.

The third group having a direct effect on estuarine infringement, is comprised of private enterprises developing water frontage for commercial and residential development. This group is perhaps the most difficult to combat for their efforts are usually made in small piece-meal developments. These developments continue slowly but surely, and before we are aware of the estuarine encroachment there is a large portion no longer available to marine resources.

Because such developments progress at such a slow pace, they are difficult to combat or even reach for consideration of mutual problems. It is also true that the agencies involved, while small, usually have adequate private funds and political pressure to successfully off-set any attempt by the conservationist to curtail or control their activities. Also in their favor is the fact that these individual developments are so small they do not appear to be worth any large objecttion on anyone's part.

At our laboratory on Dauphin Island, we are in the process of compiling and researching all available publications and reports concerning the red tide programs. In reviewing the past reports and field data we were checking a series of field stations in Tampa and Boca Ciega Bays. This work was done around five years ago, and we were completely bewildered when five of the marine stations were now on dry land, no doubt in ranch-style living rooms.

Investigations of this phenomena by obtaining out-of-date navigational charts, showed that most of this estuarine area has been filled in for housing developments.

It might be fairly well founded to state that the projects mentioned herein have occurred in every estuarine area of our country in one form or another.

It must always be remembered that those agencies and individuals who are proposing some of these projects are vitally interested in the success of such a project and are willing to devote a goodly portion of their time and their pocket book as well, to see that such developments take place in the particular manner they so desire. They are always an active and usually a well financed group with certain connections in municipal, state and governmental circles. This makes them strong opponents in any game you may wish to play. The only way by which many of these operations can be controlled is for the agencies responsible for the protection of these so-called environmental values to stay awake to the possibilities of these developments and be in a position where they can take effective action. Such action will very seldom be effective without the assistance of a well informed public and a few sympathetic listeners in the position where they can do the most good.

One of the most difficult problems that face those of us who are dependent on our marshlands and estuaries for our source of food and recreation, is the establishing of a value to use in the effective combating of such developments. It appears to many of us that the only sign of progress in this day and age is the dollar sign in the most direct and obvious manner possible. To combat this encroachment therefore, we must be able to use the weapon that is used against us and establish a dollar value on our marshland and its production of natural resources whether it be in the form of fins, furs or feathers.

Unfortunately for the conservationist, it is easier to see an industrial building, however small it may be, than it is to see natural production or the productive value of the lands and waters of the marshlands. This is not the purpose of this presentation, but it is most necessary to know that the value of these estuarine areas is greater than even the most devoted of us to this problem can realize. I quote only three figures to illustrate the dollar value of our estuarine areas in one year. In one year alone the value of the menhaden, shrimp and oyster production in the United States, all three of which depend upon estuarine areas for their continued existence, amounted to $138,270,000, and we are forgetting altogether the value of such areas as waterfowl areas, sports fishing areas and recreational sites for camping, boating, skiing and other such activities.

In Alabama our marine resources are centered in Mobile and Baldwin Counties, with a total estuarine area of 550,000 acres and an average depth of 12 feet. The entire production is closely connected with the Mobile Delta Area of 50,000 acres. This delta is the so-called "mother superior" for an industrial and recreational production totaling $18,581,000. This amount includes the categories of commercial and sports fishing, wildlife, oyster shell production, sand, gravel, and oil and gas leases. This is a production value of $37 per acre of estuarine area, including all of Alabama's coast and estuarine marshlands annually. In one generation, generally considered as thirty years, this is a total value of $557,430,000 or around $1100 per acre. This is worth trying to save.

NEW SHELLFISH FARMING

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Progress of our civilization is a double-edged process. It means that while we are rapidly advancing along the numerous creative pathways, such as general technology, agriculture, medicine, and many other fields of human endeavor, we are simultaneously proceeding with equally rapid destruction of our natural resources, such as forests, fields, and waters, as well as the organisms that under normal conditions inhabit these environments.

To be realistic, we must admit that, because of the rapid increase of human population and, in this country especially, because of the high standard of living, the increasing demands on nature and partial mutilation of it are unavoidable. In other words, the trees will be cut, the dams will be built, the harbors and bays will be heavily dredged to lay down deep channels for vessels or to establish numerous marinas for maintenance of pleasure craft. Moreover, because of the people's desire to live near the water, many inter-tidal or shallow water areas will continue to be filled to make new land on which to build houses or amusement places. Sometimes, as is the practice in Long Island Sound and many other areas, sand and fine gravel composing now productive shellfish beds will be dredged to provide material for construction of highways or houses.

In addition to all these purely physical changes, chemical changes of considerable magnitude, which should really be considered as mass pollution of aquatic basins, will continue to be profoundly difficult problems.

The growing populations of all countries will need more and more food. In some countries, especially Asia, the dry land may soon fail to provide all the food needed and, therefore, as in past centuries, humanity will be compelled to face the oceans in its efforts to obtain more food. However, we are now aware that it is unrealistic to continue considering the ocean an inexhaustible source of nutritive materials. We know that with modern efficient methods of fishing even oceanic species of fish may soon disappear. There is already some evidence pointing in that direction. Obviously, it means that we cannot depend upon aquatic hunting alone. Something has to be done to increase production of the ocean just as men of past centuries had to develop food production on dry land. We modern people, therefore, should be developing the science of mariculture, and fast.

The question arises what are the most promising branches of mariculture? This is a broad question and, naturally, I cannot answer it within the time allotted for this talk. I may generalize, nevertheless, that cultivation of some pelagic species of fish may be too difficult but that, on the contrary, propagation of invertebrates such as crabs, shrimps, lobsters, and especially mollusks, may be not only feasible but highly practical. To emphasize this, I shall give you a brief account of what progress has been made during the last few years in the methods of cultivation of some marine invertebrates and what can be done to apply this knowledge in the near future on a broad commercial basis.

As I have already mentioned, various human activities already resulted in destruction of many inter-tidal and shallow water areas which in the past served as shellfish beds. As time goes on, such areas will become more and more uncommon. It means that in the future we cannot count on natural sets of oysters or clams but will be compelled to substitute for this natural loss a supply of young mollusks produced in special hatcheries. This is the first step in the new shellfish farming. The second step will consist of raising these mollusks to marketable size. These steps, of course, call for the third step, consisting of discovery and proper use of methods to control numerous enemies and predators of commercial mollusks throughout all stages of their development.

Biologists of the U. S. Bureau of Commercial Fisheries anticipated the problems mentioned above. Exactly twenty years ago they began to develop methods for cultivation of molluscan larvae so as to grow them eventually into adults of commercial size. This wasn't the first attempt in the history of human science to achieve this aim. There were others in the past but, unfortunately, most of them failed. In our case, however, we were more fortunate. Nevertheless, the path that led to our success was not too smooth, probably because, being pioneers in the field, we had no one to help us with our difficulties.

Perhaps one of the most important breakthroughs that assured our success was the discovery of methods by means of which we can now maintain in the laboratory ripe, ready-to-spawn mollusks on a year-round basis. In the past, the natural spawning season of an oyster in Long Island Sound was confined to two or two and one-half summer months. The same was true of the common clam, *Mercenaria mercenaria,* as well as most other bivalves of the same geographic area.

Methods of conditioning mollusks for spawning are simple. We either advance the spawning by bringing the oysters and other bivalves into the laboratory in the middle of winter and subjecting them to gradually increasing temperatures so that within approximately three weeks they are ready to spawn, or delay their spawning by taking them from their natural environment to be transplanted for the summer in water of such low temperature that they develop gonads but cannot spawn. In our Milford practice, we routinely send our oysters and clams in early summer to Boothbay Harbor, Maine, where such a temperature regime assures us ripe but unspawned clams and oysters available from August through fall and even early winter.

Being able to work with ripe molluscan eggs on a year-round basis, we soon developed a reliable method for raising the larvae to setting stage. This method is also simple but has a number of variations, all of which consist basically of changing water for the larvae every two or three days, thus getting rid of metabolic products that may interfere with normal development of the young mollusks. Because of the sanitary conditions, we can now crowd larvae so much that in some instances cultures having fifty or even one hundred larvae per cubic centimeter of water in hatchery vessels were grown to metamorphosis without undue mortalities or considerable delay in the rate of growth.

Another important step in the series of events leading to success was the development of the methods of providing food for our cultures. The larvae of some species, as we found during our studies, are rather capricious organisms that will select from the multitude of microscopic planktonic forms only certain ones. In a series of extensive experiments devoted to studies of qualitative and quantitative requirements of clam and oyster larvae, we eventually came out with a list of microorganisms preferred by these two mollusks and also learned how to culture these microscopic marine algae on a mass-production basis.

To simplify the matter of feeding the larvae in commercial hatcheries, we developed methods of freeze-drying algae, thus preserving it and, therefore, assuring hatchery operators a supply of food that can be stored for a long time to be used when needed.

As soon as we were able to grow larvae, we entered into a broad study of their physiological requirements, such as optimum temperatures and salinities needed for their existence. We found a great deal, including the extent of the entire temperature and salinity ranges within which the larvae of different species can exist. We also extended our studies into the effects of turbidity upon the eggs and larvae and came out with the conclusion that larvae were not strongly affected by moderate changes occurring in their natural environment.

It is necessary to mention, however, that from the very beginning of our studies, and even now, we have been experiencing epizootic mortalities of larvae. We soon discovered that these mortalities are caused either by fungus or some other microorganism such as bacteria that are found in sea water. Fortunately, our luck held again and within a comparatively short time, we developed a number of relatively effective methods to control the diseases. For this purpose, the same as in agriculture, we began to use various agents, including certain chemicals, sulfa drugs, and antibiotics such as Streptomycin. The study of controlling diseases is continuing, and I am quite sure that within a few years we shall be able to control most diseases. Our biologists at Milford are making good progress in this direction.

Because of our ability to raise molluscan larvae from eggs obtained from known parents, we are now entering the field of genetics and hope within a short time that we shall be able to develop races of clams and oysters with such desirable characteristics as ability to propagate at lower temperatures, resistance to diseases, development of better meats, and display of more rapid growth. Preliminary experiments along this line have been extremely promising.

The second step in producing mollusks for the market is to grow them to necessary size. In our opinion this will be accomplished simply by planting the set in suitable areas where good bottoms are still available and where they are not, by suspending the young mollusks from certain types of floats as is already done in Japan, and as has been demonstrated to be practical by numerous experiments conducted by American biologists. In general, we do not think this phase of shellfish farming should present many difficult problems except in control of competitors and other enemies, a matter to be considered in the next paragraphs.

In mariculture, the same as in agriculture, control of enemies of desirable commercial species is not always a simple task. Taking oysters as an example, we know that their mortality is caused by a variety of forms living in the same environment, beginning with lowly sponges and ending with fishes. On the Atlantic coast, however, the most serious enemies of the American oyster, *Crassostrea virginica,* are small snail-like creatures called oyster drills. In some areas the common starfish, crabs, and predatory flatworms cause heavy losses. Other forms, which are not true predators but are competitors, such as mussels, tunicates, barnacles, and even hydroides, may at times cause heavy mortality of oysters, especially young ones.

Biologists of our Bureau, as well as members of industry, realized the extent of the heavy losses suffered by oysters and clams because of the activities of their enemies and diseases, and worked diligently to find methods to control some of the undesirable forms. I am pleased to state that since the time I joined the U. S. Bureau of Fisheries, we have found ways to control many pests. It is true that these methods do not always entirely stop activities of the enemies.

This is difficult to achieve even on dry land, principally because of reinfestation of the treated areas. Nevertheless, such a simple method as spreading lime over oyster beds infested with starfish may significantly reduce the population of these pests and, if repeated at regular intervals, may effectively control them.

Another simple and safe method consists of using saturated solution of common salt, immersing in it for brief periods dredge-loads of oyster set or adult oysters to kill a variety of predators and competitors such as sponges, starfish, flatworms, hydroides, *Crepidula,* etc. Dipping oysters in solutions of simple and relatively safe chemicals is another effective way to get rid of such forms as common mussels, which often invade oyster beds and compete with oysters for food and space.

Finally, several years ago we discovered an extremely effective chemical method to control snails that attack clams and oysters. This method has been described on a number of occasions. Under strict supervision of Bureau biologists, it is being tried on some commercial oyster beds in Long Island Sound and in New York waters. However, the method is still under investigation by the U. S. Public Health Service and the Pure Food and Drug Administration to determine whether it will be safe for humans to eat meats of clams and oysters grown on chemically-treated areas.

As we develop sound biological approaches for production of mollusks and effective methods of controlling their enemies, we are also thinking of improving mechanical operations to increase the efficiency of all aspects of shellfisheries. For this we work with a number of oyster companies, some of which have already established hatcheries on a semi-commercial basis. In general, the rapid progress made during the last twenty years in virtually all phases of shellfish cultivation, which I have mentioned in this article, leads us to believe that the time is not far off when these newly developed methods will be generally accepted. With these methods in wide use, we may rapidly convert our inland seas like Narragansett Bay, Long Island Sound, Chesapeake Bay, Pamlico Sound, Puget Sound, Gray's Harbor, Willapa Bay and numerous other aquatic basins of smaller size into underwater gardens that will continue to exist and function to provide humanity with excellent food. This, of course, will be possible if we manage to prevent gross pollution of our fresh and salt water basins. However, because I trust in the human mind and genius, I profoundly believe we shall solve this problem too, thus successfully combining the progress of technology with progress in practical application of biology.

DISCUSSION

DR. HARGIS: Thank you, Dr. Loosanoff. That was a very interesting and stimulating discussion.

Are there any questions or comments?

If not, I think we will have a break. Let me make one comment here, though, before I forget it.

Some of the comments after Dr. Snyder's paper were very interesting ones. I would like to comment here that the gentlemen commenting on these temporary measures were correct in their analysis of the situation. I think nearly all of us recognize that population control, human population control, is a necessary thing.

Unfortunately this is a complex problem, the solution of which will require a great deal of time and a stable international situation, as well, so that I would comment in response to these gentlemen that one of our jobs, as conservationists, is to help maintain the political stability and climate necessary to these long-range solutions, without which there will be no long-range solutions.

THE FISHES—A NEGLECTED ASPECT OF ESTUARINE RESEARCH

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INTRODUCTION

Growing concern over the destruction of our valuable coastal estuaries has stimulated new research programs which have produced much useful and interesting information concerning the estuarine environment and its inhabitants. The accumulation of knowledge needed to develop well predicated management programs is far too slow.

Estuarine or coastal fishes that are dependent on estuaries make up the bulk of marine sport fish caught on the Atlantic and Gulf coasts as determined by ORRRC Study Report 7, Sport Fishing—Today and Tomorrow (King et al., 1962). Among the eight most frequently creeled sport fish of the northern Atlantic Coast five—flounders, scup, striped bass, tautog, and American shad—are dependent on estuaries. Among the first eight for the mid-Atlantic, six—including flounders, scup, spot, bluefish, Atlantic croaker, and weakfish—are dependent on estuaries. Among the first eight for the south-Atlantic, five—including spotted seatrout, red drum, Atlantic croaker, black drum, and flounders—are dependent on estuaries. Estuaries are utilized as either spawning, nursery, or feeding grounds. The commercially valuable menhadens are also dependent on inshore nursery areas. Estuaries are, as pointed out by Rounsefell (1963), the key to our nearshore fisheries.

The steep shores of the Pacific Coast slope quickly into deep water severely restricting estuarine environments. The San Francisco estuarine complex is among the most important on the West Coast. Excellent work on striped bass, white catfish, and other estuarine fishes has been done there by fishery biologists of the California Department of Fish and Game. The gradual slope of the Atlantic and Gulf coasts, however, has resulted in many extensive estuarine areas. Therefore, it is with research on fishes of the Atlantic and Gulf coast estuaries that we are principally concerned in this discussion.

CATCH OF FISHES

The ultimate goal of fishery research is attainment of a high sustained yield. Although the yield, harvest, or catch is the ultimate measure of success in management, we have only the most fragmentary knowledge concerning catches of our estuarine-dependent coastal fishes. This is especially true for the sport fisheries.

Since 1880 the U. S. Bureau of Fisheries and later the U. S. Fish and Wildlife Service have obtained information on commercial catches which is now published annually in the well-known Statistical Digests of the U. S. Bureau of Commercial Fisheries. Although the Statistical Digests lack specific information concerning the locations where fish were caught and the amount of fishing effort, they are widely used to indicate total harvest of commercial fishes.

No such information is available on sport catch. This is especially unfortunate in view of great increase in harvest by sport fishermen as compared with commercial harvest. The National Survey of Fishing and Hunting made for the U. S. Bureau of Sport Fisheries and Wildlife (1961) has shown a 38 per cent increase in the number of persons who fished in salt water from 1955 to 1960. A continuous inventory of the estuarine and coastal sport fishery is a vital necessity for the evaluation of any kind of management program, and to determine research priorities. Research is needed to determine the types of sport fish-catch sampling programs that are best suited to obtain the necessary information for the different areas and fisheries and the amount of effort needed to develop such programs.

Some useful surveys of sport fish catches of estuarine and coastal waters have already been made by state fishery biologists—who clearly have the primary responsibility for such work. Although restricted to limited areas for relatively short periods of time, they have been of great significance in developing methods for obtaining good estimates of total catch for the areas and during the periods when they were made. Among these have been surveys in areas of New York, New Jersey, Delaware, Maryland, Virginia, Florida, and Texas. (Alperin, 1958; Briggs, 1962; Younger and Hamer, 1954;

Younger and Zamos, 1955; Harmic, 1956; Walker, 1954; Elser, 1960; Shearer, et al., 1962; Richards, 1962; Rosen and Ellis, 1961; Moe, 1961; Belden Associates, 1958.)

Collectively, these studies have contributed only a small fraction of the information needed for proper evaluation of sport catch in estuarine and coastal waters. Since most estuarine fishes range widely along the coasts, with many states harvesting fishes from common stocks, there is a need for comparable information on the sport catch from all coastal states. Where both sport and commercial fishermen harvest the same fish populations, catch information from both commercial and sport fisheries must be integrated. Fishery biologists working in southern reservoirs have proposed standard methods for reporting creel survey data for reservoirs (Lambou, 1963); while not strictly applicable to estuarine and coastal waters, a uniform system of reporting creel survey data is definitely needed by coastal state fishery biologists.

While knowledge of both the magnitude of catch and fishing effort of estuarine and coastal fishes is essential, it is by no means sufficient for a full understanding of population trends. A characteristic of many estuarine and coastal fish populations is the irregular and often extreme fluctuations in abundance, generally caused by successful or unsuccessful spawning or survival from spawning. Such fluctuations are often independent of the numbers of spawners. Extreme changes in population size are known to have occurred with spot, weakfish, Atlantic croaker, bluefish, and striped bass. Continual monitoring of catches for age composition is therefore necessary. Juvenile fish surveys, population sampling and extensive tagging programs are also needed to evaluate population trends, natural mortality, migration patterns and harvest rates.

LIFE HISTORY OF FISHES

American shad has been the focal point of one of the most intensive research programs on Atlantic estuarine fishes. Shad research has clearly shown that successful management of the fisheries can result from findings of a well executed research program. The U. S. Fish and Wildlife Service, with the assistance of state fishery workers, demonstrated that management of the Connecticut and Hudson River shad runs was primarily dependent on escapement of sufficient numbers of spawners (Fredin, 1954; Talbot, 1954; Walburg, 1963). The collapse of the Delaware River shad fishery, formerly the largest on the Atlantic Coast, was mainly attributed to extensive pollution of the Delaware estuary which blocked spawning runs, caused complete mortality of post-spawning fish, and was damaging to the juveniles as they migrated seaward (Sykes and Lehman, 1957). Lack of adequate records of shad catch and fishery effort for a sufficient number of years precluded the establishment of a definite relationship between the size of parent stocks and subsequent runs in Chesapeake Bay and rivers on the South Atlantic Coast. Success of the shad research program was dependent on the ability to accurately determine age of the fish (Cating, 1953) and on a general understanding of their coastal migrations (Talbot and Sykes, 1960).

American shad is one of the few estuarine fishes not neglected by research. Positive recommendations for proper management of the fishery have resulted from this work but much remains to be done. The success of the fishway at Holyoke Dam on the Connecticut River in both the passage of adult and juvenile shad over this formerly impassable barrier has resulted in a substantial increase in Connecticut River shad runs. The possibility of passing shad over a series of four dams on the Susquehanna River is now being investigated and the use of navigation locks for this purpose is being considered in southern rivers. Futher evaluation of both the Delaware and Susquehanna as spawing and nursery areas is needed. Efforts to obtain information on both shad catch, fishing effort, and age composition of shad populations must be continued and further efforts must be made to develop adequate methods for estimating numbers of juvenile shad in up-river nursery grounds.

Striped bass has received almost as much attention from research as American shad, yet the most important questions concerning its management remain largely unanswered. Studies on the life history were summarized by Raney (1952). A series of studies on the racial structure of Atlantic coastal populations by E. C. Raney and his students have shown that Hudson River and Chesapeake Bay striped bass consisted of separate sub-populations, as did fish from rivers south of Cape Hatteras. Subsequent tagging studies have demonstrated that these sub-populations intermingle in coastal waters from North Carolina to New England (Chapotan and Sykes, 1960).

Striped bass are harvested in large numbers by both sport and commercial fishermen. Biological studies are needed to determine if striped bass stocks can maintain their present levels of abundance in the face of increasing fishing pressure. If it is determined that they cannot, best use of this resource would be as a sport fish. Studies on the estuarine white catfish in California, which demonstrated overfishing under combined commercial and sport harvest, resulted in this fish being properly managed solely as a sport fish (Pelgen and McCammon, 1955). Quantitative estimates of juvenile abundance must be related to the abundance of these same year-classes in subsequent catches and the effects of different length limits must be determined.

Summer flounder has been of special interest to New York, New Jersey, and U. S. Fish and Wildlife Service biologists. Research in Great South Bay, New York, has demonstrated a high rate of exploitation on small fish by sport fishermen and has suggested the need for a 14-inch size limit to protect them (Poole, 1962). If this recommendation is adopted, it will be followed by an evaluation study.

Tagging studies have shown spring and summer movements of adult flounders along the coast are inshore and to the north, followed by an offshore and southward movement in the fall. Further large-scale tagging efforts are needed to clarify the migratory pattern. Systematic studies of the morphology of samples of small flounders are needed to ascertain if separate coastal populations are present or if flounder stocks consist of a homogenous group of fishes. There is limited information on flounder spawning areas but the location of these areas needs to be clearly defined as do the nursery areas of both larval and juvenile fishes. The eggs and larvae have not been differentiated from closely related southern flounders; therefore, descriptive studies are needed to enable biologists to distinguish them in plankton collections.

Winter flounder utilize inshore spawning and nursery areas. Studies of larval and juvenile distribution, abundance, growth, and population dynamics were investigated on a quantitative basis in the Mystic River, Connecticut (Pearcy, 1962). Seasonal movements of the flounder along the Atlantic Coast have been outlined, and studies in New York have shown that these fish consisted of a series of local populations which could be managed on an individual basis.

Further work on the winter flounder should include more extensive surveys of spawning and nursery areas, especially in those estuaries which are in danger of destruction. Needed are possible means of compensating for such losses and continued surveillance of catches both for quantity and age composition to detect for possible overfishing.

Weakfish is among the first estuarine fishes whose age could be determined from scale examination (Taylor, 1916). In spite of this early start, few subsequent studies have been made. Among the most significant research on weakfish have been the extensive studies of length and age composition, magnitude of catch, and tagging which indicated the complex migratory behavior of weakfish along the mid-Atlantic coast (Nesbit, 1954). Continuation of these studies suggested that southern spawned stocks contributed substantially to New York weakfish populations and emphasized the need for cooperative studies by mid-Atlantic states. Research in Chesapeake Bay emphasized the importance of estuaries as nursery areas for young weakfish and studies on age composition of commercial catch demonstrated the need for definitive studies on weakfish migrations in order to properly evaluate the effects of fishing mortality on weakfish stocks.

Among the most important of Atlantic Coast estuarine fishes, weakfish has received scant attention from research. In addition to obtaining detailed information on migrations, future studies should determine the effect of fishing on total mortality.

Spotted seatrout was poorly known until recent years. Productive studies in Florida by Tabb (1961) and others, on life history, movements, and mortality (both fishing and natural) have shown the dependence of seatrout on shallow, grassy estuaries. A summary on the biology of seatrout in Gulf waters was completed by Guest and Gunter (1958).

Needed is more quantitative information on the effect of habitat destruction on seatrout populations as well as biological studies on spotted seatrout in Atlantic coastal waters where they make extensive migratory movements.

Atlantic croaker is among the most neglected of estuarine and coastal fishes. Distribution of young croakers in estuaries was described by Haven (1957). Drastic declines in croaker of Chesapeake Bay were believed to have been a result of winter mortalities of juveniles caused by abnormally cold water in brackish water nursery areas (Massmann and Pacheco, 1958).

Controlled temperature experiments are needed to determine temperature levels at which normal activities are interfered with, and at which mortality occurs. A satisfactory method of age determination must be devised and validated. The croaker egg has never been identified, nor have offshore spawning grounds been discovered, in spite of intensive efforts to find them. More intensive studies are needed to assess the effects of fishing in croaker stocks and further efforts are needed to define croaker populations and to determine the amount of movement.

Spot has received less attention from research than croaker. Dominant year-classes sometimes occur. The life span is short; few spot live to be three years old and almost none survive to reach four (Pacheco, 1962).

The spawning areas, eggs, and early larval stages have not been described. Natural mortality and harvest rate should be determined to ascertain the proper size for harvesting spot. Extensive tagging programs would give more complete information on migrations and further food habits studies should indicate the degree of competition between spot and other bottom fishes.

Red drum (*redfish,* or *channel bass*) is a popular sport fish, yet it has received little research attention. In Texas the life histories of both the red and black drum have been studied by Simmons, and Breuer (1962). The eggs and larval stages are unknown. Atlantic coastal populations have never been defined, nor is there any information on the extent of Atlantic coastal migrations, rates of growth in Atlantic waters, or the effect of fishing on red drum stocks.

Black drum have also been neglected. In addition to the research already indicated, spawning areas, eggs, and early larval stages have only recently been described (Joseph, et al., in press). The effectiveness of commercial netting in reducing stocks of black drum in Texas needs further evaluation and more detailed life history studies should be completed, especially on Atlantic coastal waters. Further work is needed to assess the damage by black drum to both oyster grounds and the spawning and nursery areas of more desirable fishes.

Scup (*porgy*) is among the most important fishes of the mid-Atlantic coast, yet no comprehensive scup study has ever been published. Biologists of the old U. S. Bureau of Fisheries did much work on this species, the results of which will soon be available. There is an urgent need for basic life history studies of scup and an evaluation of the effect of both sport and commercial fisheries on the stocks. Needed is information on the utilization by scup of artificial reefs and determination on the extent to which estuaries are utilized as nursery areas.

Tautog is another of the neglected estuarine fishes. Recent work in Rhode Island, which included tagging studies, has indicated only small migratory movements. Growth is relatively slow and the possibility of overfishing by anglers and spear fishermen does exist (Cooper and Chenowith, 1963). Systematic sampling of catches on a continuing basis is needed to determine possible changes in age composition. Further studies of tautog in other areas are needed.

Bluefish utilize inshore feeding areas as juveniles. In spite of their wide popularity as a sport fish, bluefish have received little attention from research. Age, growth, and spawning ground studies of bluefish in Massachusetts, New Jersey and Virginia have been completed but the results of this work have not been published.

Major spawning and nursery areas of bluefish are as yet unknown and suggested patterns of coastal movements have yet to be demonstrated. Age and growth have not been verified. Possible causes for marked changes in abundance are not known, nor are the effects of fishing and natural mortality. Limited studies of bluefish, now under way at the Sandy Hook Laboratory of the U. S. Bureau of Sport Fisheries and Wildlife and several state fishery stations, are just beginning to scratch the surface of this most important fish problem.

In view of the paucity of knowledge of our most important sport fishes, it may be appreciated that information on less popular species is even more scanty. Few studies have been made on the behavior or physiology of Atlantic and Gulf coastal estuarine fishes.

ENVIRONMENT AND FISHES

Effects of environmental factors on estuarine and coastal fishes have received little more attention than studies on the fishes themselves. Spectacular fish mortalities that have been caused by unfavorable conditions have been well described. The more subtle effects of small changes in environment may be of greater significance in determining abundance of fishes, however. The effects of such changes are still obscure.

Temperature influences fish distribution, numbers, and catches. Mass mortalities of croaker, spot, spotted seatrout, and both red and black drum have occurred in Gulf and Atlantic coastal estuaries. Among the most significant contributions concerning the effect of temperature on fish populations is that by Gunter (1952), who estimates that from 25 to 30 million pounds of fish were destroyed in Texas bays between 1940 and 1951.

Recent interest in offshore water temperatures has been greatly stimulated by the development of airborne infrared surface temperature scanners. Great expanses of sea surface may be surveyed rapidly, giving an almost synoptic picture of surface water temperatures. Such surveys are little more than novel exercises, however, unless parallel data are also obtained on distribution and abundance of fishes in areas surveyed.

Other natural factors of importance in research on estuarine fishes include the effects of hypersalinities such as those which have occurred in Laguna Madre on the Texas Coast, effects of storms, and the effects of the widely publicized "red tides" in Florida. In addition to learning more about the causative agents of these catastrophes, further efforts are needed to determine the total effects of such mortalities on fish populations involved and resulting fishing success.

With the exception of the sea herring epizootic, reported by Sinderman (1958), disease among estuarine and coastal fishes has received little attention. Extensive mortalities of white perch occurred in Chesapeake Bay in the summer of 1963. The immediate cause of these deaths was a bacterial disease; however, the conditions which fostered the epidemic probably included environmental stress from higher-than-average salinities and overpopulation. In addition to learning the immediate causative agents of such mortalities, it is necessary to discover the environmental factors which foster them. The possible use of specific disease-producing organisms for control of overabundant and/or undesirable estuarine fishes should be considered as a possible management tool.

Among the man-created environmental factors affecting the abundance of estuarine and coastal fishes, pollution is among the most serious. The damaging effects of pollution on shad have been widely recognized. Pollution-caused fish kills are serious. Of greater significance is the destruction of fish habitat by pollution. Key habitat areas, such as nursery and feeding, are being totally eliminated or seriously damaged. Recognition of the need for research on estuarine and coastal pollution has stimulated approval of funds for the new U. S. Public Health Service laboratory at Narragansett, Rhode Island, which will be devoted to research on water quality criteria for aquatic life in salt water.

One of the most difficult problems which confront fishery biologists is assessment of damage to fish populations and fisheries by engineering structures. The effects of dams which completely block spawning runs of anadromous fishes are readily recognized. The changes in water quality that result from such dams, and development of methods to preserve blocked populations or to compensate for their loss, are more difficult to develop.

Widespread changes in salt-marshes and estuaries are being made by intensive shore development in many areas. Filling, bulkheading, and dredging are rapidly changing sensitive estuarine spawning, nursery, and feeding areas. Specific studies must be made which demonstrate not only how these areas contribute to the success of individual fish species involved, but quantitative measures must be developed to demonstrate the degree to which fish populations are being affected.

Estimates of the productivity of salt marshes have demonstrated that these areas are more fertile than either uplands or the sea (Odum, 1963). Most of this production is in the form of organic detritus which is eaten directly by some fishes, but most is utilized by invertebrates which later may be eaten by fishes. The difficulties in relating primary productivity to yield of fishes have been pointed out by Rounsefell (1963). Further work is needed to show the extent to which the high plant production of salt marshes and estuaries actually result in high production of desirable fishes and suggest ways to improve upon such translation.

Among the most significant contributions to estuarine studies on fishes have been those made in northern Florida Bay which predicted the effects of alteration of drainage patterns in the Everglades on estuarine fish populations (Tabb, et al., 1962). Well planned dredging to enlarge existing grass flats and restore flats that have been destroyed has been suggested by Strawn (1961).

Research is needed to determine the factors which make estuaries such an indispensable link in the life cycle of coastal fishes. A pilot study on a series of estuaries in which different factors could be altered singly or in groups would aid in our understanding of estuaries. Such studies might result in methods for minimizing or compensating for damage to these waters, or even improving the value of estuaries for coastal fishes.

Among the most promising methods of improving estuarine and coastal sport fishing has been the development of artificial fishing reefs. By 1961, twelve states had one or more artificial fishing reefs (Stroud, 1961). There is, however, a need for comprehensive studies of fish populations in an area before the construction of a reef, followed by an analysis both of fish populations associated with the reef and catches of fishes from the reef vicinity. Evidence exists that reef populations consist both of migrating fishes that concentrate at the reef for varying periods of time, as well as permanent reef residents. The pilings of fishing piers, bridges, offshore oil well structures, and old fish net stands also attract fish. Studies of these might demonstrate the feasibility of using other types of piling structures for concentrating estuarine and coastal fish populations.

Regulation of fish catch is only one of a number of possible measures that can be employed in maintaining fish stocks at high levels. Such regulations must be based on a firm biological basis and their effect needs full evaluation. Escapement of an adequate number of spawners has been advocated for shad in both Hudson and Connecticut Rivers. Studies of summer flounder in New York have indicated that a 14-inch limit would benefit the sport fisheries. Liberalization of restrictions on white perch have been suggested in Maryland.

Most length limits on marine fishes were adopted prior to the time when there was adequate biological information on fishes they were to conserve. Regulations should be carefully re-examined. If found to be of questionable value, they should be discarded.

SUMMARY

The bulk of marine sport fish of the Atlantic and Gulf coasts are dependent on estuaries for either spawning, nursery, or feeding

grounds but the accumulation of knowledge for management of our estuarine fishes is far too slow. A continuous inventory of the sport catches of estuarine-dependent coastal sport fishes—clearly a state agency responsibility—is especially necessary. Extensive life history studies on Atlantic shad have resulted in definite recommendations for proper management.

Striped bass research has uncovered a wealth of useful basic information but has left the most pertinent questions concerning proper management still unanswered. Further detailed life history, ecological, and behavior studies are needed for our most important, estuarine-dependent coastal fishes including the flounders, weakfish, spotted seatrout, Atlantic croaker, spot, drums, scup, tautog, and bluefish, as well as for fishes of less importance. Much information is needed on fish population dynamics.

Also needed is further information on the effects of environmental factors, including temperature, salinity, storms, disease, pollution, and engineering structures on fish populations. Basic studies on the fishes in estuaries should ultimately result in methods for minimizing or compensating for damage to these waters, or even improving the value of estuaries for coastal fishes. The use of artificial reefs by sport fishes needs to be clearly evaluated by quantitative studies made before and after the construction of such reefs. Catch regulations, where needed, should be based on the results of biological studies and their effects should be thoroughly evaluated.

The short-term, problem-solving management investigations should be undertaken by the states. The more basic, generally long-term research on detailed life histories and ecology, behavior, and population dynamics of estuarine and coastal fishes should be conducted principally by federal and academic laboratories.

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DISCUSSION

MR. DOUGLAS HEY (Cape Province Department of Nature Conservation, Cape Town, South Africa): I have listened to this paper with very great interest, Mr. Chairman. There is one aspect of estuarine research that I happen to know something about. The speaker covered a very wide field, but he couldn't cover everything, and there is one aspect that worries us very much, and that is the question of estuarine bait organisms.

I would like to explain to these gentlemen that in our country we have turned our estuaries over to recreational fishing. We find that our estuaries are far more valuable as a recreational facility for our people and they bring a far greater return used as a recreational resource than to use them for commercial fishing. But the big problem which we face at the moment is that our estuaries are being invaded by bait organisms and the result is that we have the fish but we haven't the bait to catch them with, and I would like to know whether any work is being done in this respect.

MR. MASSMANN: There has been none to my knowledge on the Atlantic Coast, although there has been a considerable amount of discussion concerning the anchovy fisheries in California, but this is not strictly an estuarine fishery.

I would like to say to your comments about the use of estuaries for the use of recreational fisheries that we are in wholehearted agreement with this philosophy.

DR. HARGIS: Are there any other questions or comments?

MR. GORDON FREDINE (National Park Service, Bethesda, Maryland): I have been very much interested in the papers given here today, and this last one also. It prompts me to call your attention to your National Park System and the opportunities that it offers.

As you know, our major objective on coastal and estuarine areas that are under our jurisdiction is to preserve and protect the natural integrity of these environments. I would like just quickly to go around the continent with you and to remind you of what is here.

Starting even north of the United States boundary, on the eastern seaboard, there is Campobello Island which is jointly operated now, or will be, by Canada and the United States.

Below that is Acadia National Park, and the shorelines and island areas near Bar Harbor.

Going down farther is Cape Cod National Seashore; then on Long Island there is the proposed Fire Island National Seashore.

Then, going farther south, there is the proposed Assateague Island National Seashore; then on down to the existing Cape Hatteras National Seashore in North Carolina.

Before I forget it, I want to mention the Virgin Islands National Park on St. John Island and the Buck Island National Monument on Buck Island and its associated reefs near St. Croix.

Perhaps one of the most important is Everglades National Park, including the estuarine areas there and the adjacent keys, where, in this large part of Florida, there is the last remaining and perhaps the only place where natural conditions can be preserved in that region. There very important work has been done by the Marine Laboratory at Coral Key.

Then beyond Key West, in the Dry Tortugas, we have Fort Jefferson National Monument. Incidentally, we have recently suffered a disastrous oil spill around the islands.

Then, going down the Texas Coast, Padre Island, the new National Seashore in Texas and, jumping across to the Pacific, starting at San Diego, Cabrillo National Monument has a small but important coastal area near San Diego. Going on up the coast there are the Channel Islands off Santa Barbara and the proposal for enlarging this national monument and perhaps making it a national park.

On up the coast just beyond San Francisco is the new Point Reyes National Seashore. Further up in Oregon there is the proposed Oregon Dunes National Seashore. On up into the State of Washington there is the Olympic National Park with its important ocean strip. Then on up into Alaska there are the huge Katmai and Glacier Bay National Monuments, with some minor coastal areas in Hawaii.

What I want to call to your attention in particular is the fact that these areas are your areas; that they are available for research, they are available for study, and we invite this, because not only do we want to advance the scientific knowledge but we need more basic data so that we may properly protect and manage these areas. So we hope that you will consider these opportunities and get in touch with us and you will find a warm welcome in the National Park System for the advancement of marine fisheries knowledge in our country.

MR. GEORGE W. ALLEN (Montgomery, Alabama): In answer to the gentleman from South Africa, I believe, sir, unfortunately I didn't go through there on my way out here so I am not too familiar with it. In a study of your biometrics, as we call it, I can not speak for the East Coast, but on the Gulf Coast—and I would imagine your conditions are somewhat similar—there have been intensive studies started and conducted by the Bureau of Commercial Fisheries at Galveston, by our own laboratory at Dauphin Island in Alabama. In fact all state laboratories on the Gulf Coast, and federal laboratories as well, are well aware of the necessity for basic information on this project, and after the session I would be very happy, sir, to speak to you, and I can give you addresses of persons whom you should contact.

MR. ROBERT SIMPSON (Moorhead, North Carolina): I would like to point out to this group that there is a great void, apparently, along the southeast Atlantic. I noticed that there never has been any great emphasis on the area from Hatteras to Northern Florida, even on the modern maps, typographic maps. That is a pretty well skipped area.

This is something that is real close to me because I have been working on something for about two years as hard as I can.

We had a bill introduced and sent to the Insular Affairs Committee on October 17, asking that an area, namely Cape Lookout National Seashore Park, be established. I have been attending several lectures here and talking with quite a few people, and I have discovered that nobody knows about this.

This happens to be, in my opinion, North Carolina's, South Carolina's and Georgia's most completely neglected area of any research. It is also the area of the largest estuarine acreage, I would say, that there is along our coast, and

I would like to offer to this group consideration of Cape Lookout. It is a wonderful place if they are interested in this sort of research, because it does involve a big area, large sounds, large rivers, the ocean; you have the capes there, and you also have a close proximity to both northern and southern fish. I think it would be worth considering.

MR. HERBERT ALLEY (Florida Wildlife Federation, Key Haven, Florida): The problems discussed here this morning are extremely interesting as far as biological research is concerned. I'm sorry that it was necessary to maintain a negative approach to the whole thing, and my question is this: How can we get information, enough statistics that are reasonably reliable, that we may use in some of our fights against some of the urban developments, projects of the Corps of Engineers and many things that we all know about? We can't wait twenty years for these answers. We must have some of the answers now—at least enough to go on in order to be able to accomplish, or prevent, I should say, some of the developments that are being so destructive in our estuaries.

How do we go from here? I mean, what can we expect from you biologists that will give us a hand on this thing? I would like a rather direct answer on that if I may, please.

DR. HARGIS: I suspect that this would be primarily directed at all of us, so I will assume the prerogative and attempt an answer.

This is, of course, a problem with which we are faced all the time, our apparent inability to give figures or data precise enough to have any effect in the day-to-day attempts to conserve the estuaries. It's a real problem based upon a lack of information.

Part, however, is due to a difficulty of putting data of the nature that we have up against dollars, and I don't know whether there is any easy solution. I would suggest one of the things we might do is to be a little less conservative in our own statements to management bodies.

There is one danger, however, in not being careful, as scientists usually are at some times over-careful, and that is, when you get in a court of law before management decision agencies, you can be pressed too easily into a situation where you have to acknowledge your data, and the bases on which your statements are being made. Unfortunately, I feel that sometimes the opposition, if we would choose to call it that, is not in the same position. They can talk about dollars and they are much freer to hypothesize likely events than we seem to be.

However, a direct recommendation would be for us to be less careful in our comments to the management agencies, or less cautious. Let's put it that way.

Would anyone else like to attempt a comment?

MR. JOHN S. GOTTSCHALK (U. S. Fish and Wildlife, Boston, Massachusetts): We appreciate Bill Massmann's review of the neglect in the field of estuary research. My questions are quite simple. The first one is, who is neglecting this research? The second one is, why are we neglecting this research? And the last question is, what are we going to do about it?

DR. HARGIS: Bill, I'll pass that one on to you. You have two minutes.

MR. MASSMANN: Biologists are not neglecting this aspect. I think that most of the work that has been done has been extremely well done and it has just been a question of too little and too late.

DR. HARGIS: Could I comment on this?

John, I would like to comment on this briefly. Bill's talk was largely on marine sport fisheries. Many of these species are also commercial, as you know, and the Bureau of Commercial Fisheries is conducting what we consider to be a pretty high level of estuarine research, concentrated mainly in the Gulf. The Bureau is spending on pure estuarine work probably upwards of two million dollars a year.

We are also doing a great deal of work on shellfish around the country, in the North Atlantic and some on the West Coast, and so forth. So I think as far as the commercial fisheries go, and I hope some of this rubs off on marine sport fisheries, I think a lot is being done.

We all know that we haven't been as successful in getting appropriations for marine sport fish research, but I believe these are increasing, are they not, under your Bureau?

MR. MASSMANN: I have one more question to answer. John had one more question that was asked, and that was, "What can we do about it?"

I might mention, of course, we certainly need increased appropriations from both the Federal and the State governments, and I think perhaps one of the most significant points that could be brought out here is the need for salt water fishing licenses to finance research in those states where no license is now available, or they have no license.

MR. ALBERT H. SWARTZ (Annandale, Virginia): I would just like to take a minute here on this question of who is doing the work, who should be doing it, and what is being done.

I am now speaking for the Bureau of Sport Fisheries and Wildlife. We are attempting to meet some of the gaps. We don't think we have the entire responsibility. We feel that we share this with the states, and perhaps our program should be more of a back-up program on some of the longer-range programs.

In 1959 Congress passed a law, the Marine Game Fish Research law, which authorized the Secretary of the Interior through the Bureau of Sport Fisheries to undertake a marine game fish research program. It has been only a few years since this program was launched. We have a laboratory at Sandy Hook, New Jersey, on the Atlantic Coast, and we have another one at Tiburon, California, on the Pacific Coast, and as I say, we recognize all of these gaps and we are trying to meet some of them as fast as we can.

For example, on some of the problems that Bill Massmann brought up, the statistics on catch and effort, one of the first things we did was to have a survey on salt water angling nation-wide, and some of the statistics that he cited before, of 7 million salt water anglers, 80 million man days of recreation, three-quarters of a billion pounds of fish, came from this survey. So we have our first broad look at the dimensions of this fishery and what it is worth.

This isn't the answer. It has to be done annually the same way that commercial fishing statistics are taken. But at least we have something to start from.

Life histories—we have made a small start there. We have investigations on the red drum. This is one of the species that was mentioned, and bluefish is another. On the West Coast we have a student at Oregon State working on surf perch.

On estuaries we are attempting to get at the problems of estuarine productivity through the use of algal indicators, using them in bioassay procedures.

Another problem that Bill Massmann brought up was the relation of environmental factors to important fisheries, and we have started a program. It is a cooperative one. We don't take credit for this. We are one of the cooperators. But it is almost all along the Atlantic Coast now, and about a third of the Gulf Coast and in various areas on the Pacific Coast where we are taking sea surface temperatures by aerial measurement. We have what we call an infrared thermometer. This gives us almost a synoptic picture of temperatures all along the coast, and when we get the information on fish abundance and distribution, put together with this information, I think we are going to understand a lot more of what the effects are of temperatures in relation to the movement and distribution and abundance of fishes.

I want to emphasize that we recognize that there is far more than all of us can do. We hope to back up the States in what they are doing on this program.

One other thing that is outside of the Marine Game Fish Research program, but almost all of the investigations that Bill Massmann mentioned that are being conducted in the States were also done in a cooperative program between the Bureau of Sport Fisheries and the States through the Dingell-Johnson program. The state studies that were cited on flounder, bluefish and many other species were done through this Dingell-Johnson Federal Aid to Fish Restoration program.

AN ANALYSIS OF SPACE DEMANDS FOR WATER AND SHORE[1]

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Water is the focal point for much outdoor recreation. Scarcely a recreation facility is conceived that is not closely associated with surface water. In order to provide optimum management we should, therefore, know something about the demand for this resource and its capabilities for supplying the forms of water recreation desired.

In Wisconsin the means for examining the resource base and aspects of water recreation was provided by a law which required the Wisconsin Conservation Commission to set up a system of classification of lakes and streams by use.[2] With this mandate, we began collecting data on lakes and streams which would give a quantitive and qualitative appraisal and picture of the use opportunities for the lakes and streams in the state, a county at a time. Although the project is only about 50 percent done at this point, many facts are evident from the data which have importance in shaping public policy.

Water recreation is not usually thought of as being a consumptive use but there is no doubt that many phases of aquatic recreation are highly consumptive of space on both water surface and shore. Statements by Eddy (1963) and Stroud (1962) and others will bear this out. In addition, the various uses are competitive with one another. As a consequence, it is desirable to know the nature of recreational demand for an appreciation of consumptive and competitive aspects for guidance in managing the resource. We have accumulated data of this kind from counts of participants, creel censuses and other sources.

Numerous studies have analyzed the resource base and reviewed uses. The most massive evaluation of outdoor recreation has come from ORRRC which reviewed existing demands and took a long-range view of the future requirements of outdoor recreation (CORC, 1963). Among the facts cited was that the most important of the recreational demands was for scenery of which water is commonly the focal point. This was followed by swimming, fishing and boating of one form or another. To meet the demand for these activities, great amounts of surface water and public use opportunities in conjunction with them are required. The National Park Service as well as ORRRC has provided an inventory of present shore use on major bodies of water which has shown the character of the shore and its ownership (Na-

[1]Read in title.
[2]Wisconsin Statutes, Section 23.09 (7) (m).

tional Park Service, 1959, ORRRC, 1963). This inventory emphasized the need for national sea and lake shores and for day-use facilities in the vicinity of metropolitan centers. The State of New Hampshire provided a study of the shore use of Lake Winnipesaukee (New Hampshire, 1949). More recently the State of Michigan has engaged in an inventory of the quantity and quality of the inland waters within its boundaries (Humphrys, 1962).

These studies have not paid much attention to interactivity competition, only suggested more resource and more accommodations. In this discussion, I intend to stress the physical requirements of each activity and prospective demands for quality recreational water and shore space and develop an appreciation of interactivity competition with particular reference to the inland lakes of Wisconsin.

NATURE OF DEMAND

The demand for aquatic recreation may be lumped into several major classes including esthetics, swimming, fishing, boating, aquatic life study and observation, hunting and trapping (Table 1). To be sure there are many other classes and subclasses of activity which might be listed in the summertime recreational list, but on examination they are either relatively minor or they combine the activities named. Many who have viewed aquatic recreation provide a list of active and passive activities in their genetics but this is really not necessary. Those who picnic on the shore, hike along the shore or

TABLE 1. APPROXIMATE DEGREE AND INTENSITY OF PARTICIPATION AND SPACE CONSUMPTION BY VARIOUS AQUATIC ACTIVITIES ON THE INLAND LAKES OF WISCONSIN.[1]

Activity	Degree of Participation (% of population)	Intensity Rating (% of year)	Space consumption	Open water Space consumption	Unit of Measurement
Esthetics	50	67	High	Low	Space, miles of shoreline, acres of littoral
Swimming	50	30	High	Low	Speed and time, 2 mph, short times
Fishing	25	83	Medium	Medium	Space, 1 acre
Motorboating (including skiing)	20	42	Medium	High	Speed and time 20 mph-fast boats unlimited
Canoeing and Rowing	10	42	Low	Low	Speed and time 5 mph-unlimited
Sailing	1	42	Medium	Medium	Speed and time 5 mph—unlimited
Wildlife Observation[2]	25	67	Medium	Low	Space—acres of marsh, miles of shoreline
Duck Hunting	2	12	High	Medium	Space—acres of marsh miles of shoreline, 150 yards spacing
Trapping	1	12	High	Low	Space—acres of marsh, miles of bank

[1] Source: Wisconsin license sales data, Threinen (1961), U. S. Fish and Wildlife Service (1960), Fine and Werner (1961) and ORRRC reports.

[2] A consolidated heading under which the element of aquatic life study is lumped as well as recreational observation. Much of the heading might also be listed under esthetics.

drive along the shore basically have water esthetics in mind as they do so. The person who lies on the beach for the sun still has the esthetic or the swimming activity as his excuse for doing so. Similarly the skin diver is motivated by his love for swimming, the underwater fishing or the esthetic opportunities offered by the different and exciting underwater environment.

Each aquatic activity has a space demand on the water and on the shore and competes to some extent with other activities. To show the nature of competition and the spatial demand, the primary activities are described in some detail beginning with esthetic demand.

Perhaps the most important ingredient in the esthetic demand for water is just space. The city or country dweller can look out across the expanse of water unobstructed by factories or apartment houses. With this dimension, all the events of nature, whether sunrise, lightning storm, cloud formations or blue sky, can be viewed at their best. Secondly, I would list motion in the form of waves and currents. Water in motion whether a stream or a lake has the same fascination as a dancing campfire—it's entrancing. In the summertime, it also has a significant cooling effect. Whatever the vantage-point, these physical values will always be present and enjoyable provided there are not counteracting negative factors such as excessive odors from pollution or algae or excessive noise. Besides the physical attributes of the water, several water-derived resources contribute to the esthetic experience. These may include the water-skimming tern, the different types of fish swimming in the shallows, the wedge of ducks, the croaking of a frog, the brilliant blossom of the water lily and many others. The wild shore with contrasting water, marsh and woodland frontage offers the greatest value. Part of the esthetic experience also lies in observing man's activities such as the sailboat fleet or the graceful diver. In reality, the flat surface of water alone has little esthetic value without the contrast of shore and water and the element of space. Water space is valuable just so long as the shore is in view. The center portions of large lakes such as Lake Michigan are relatively worthless esthetically. The esthetic experiences in themselves have no prospect of damaging water quality, but they can compete with other activities because they have a spatial requirement for both shore and water.

If one were to rate esthetics in relation to other activities centered on water, it would rate high. Why else should scenic roads be built close to water, and lands fronting on waters become so built up with cottages, parks, and resorts? The esthetic experience can be obtained from all types of waters, from the little brook to big river and from the farm pond to large lakes. Participation by 50 percent of the public is estimated.[1]

The swimming activity is centered near the shore, concentrated within the 5-foot contour but extending out to the 10-foot contour. Ordinarily much more time is spent out of the water than in, so the need for shore space may be greater than the need for water space. In my opinion, the spatial requirement is about equal. Although less time is spent in the water, more space is needed for swimming about and for maintenance of reasonably safe water quality conditions—a *B. coli* count of less than 1,000 per cc. The ORRRC report (1963) on shoreline recreation resources listed a shore space requirement of 100 square feet per person for a public beach in a metropolitan area. A beach 30 feet deep could then accommodate three swimmers for each 10 feet of shoreline.

Intensive use of a swimming area such as at a public beach will result in the complete destruction of all rooted or attached plants and animals to the depths utilized. Under less intensive use where human activity is not intensive enough to keep a shore free of vegetation, such as is the case with cottage ownership, dense weed beds in sufficiently fertile waters can also be a problem. People wish to provide the cleanest most antiseptic conditions for swimming. As a consequence, they wish to create a sand bottom if one does not exist, eliminate the weeds if bothersome, and control algae if a nuisance. Optimum circumstances for enjoyment require piers and rafts. Swimming will be most enjoyed on a sandy beach with clear water. Basically these qualifications are best met by the wave-washed shore of the medium sized and large lakes.[1] Waters of lesser size require improvement to meet these conditions. Waters too fertile and growing dense quantities of algae prove unacceptable to many and bloom conditions reduce water visibility and can cause such odor conditions that swimming is impossible. Several lakes in Wisconsin have reached this stage.[2] Furthermore, some species of algae have exhibited toxicity to animals which were sufficient to cause closure of beaches at Storm Lake (Iowa) (Rose, 1953).

Swimming and related activities are one of the most sought after aquatic activities. Estimates by ORRRC (1962) indicate 45 percent of the public engages in the activity. I have always felt participation runs higher than this because virtually all children, most young

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[1]The ORRRC report (1962) calls water the focal point of most outdoor recreation and lists sightseeing, picnicking, hiking and camping among the top activities. These and other data are the basis for listing 50 percent participation.

[1]Small lakes are defined as those less than 100 acres; medium sized lakes as those 100-1,000 acres; and large lakes are those over 1,000 acres.

[2]Blue-green algae blooms on Lakes Waubesa, Kegonsa and Koshkonong in southern Wisconsin especially have at times become so dense that swimming has become impossible.

adults and many parents and older people, engage in swimming. I have estimated participation at 50 percent of the public because opportunities run high in this state although climate can sometimes be antagonistic. Evidence of the demand on natural lakes in Wisconsin can be seen in the much higher market value of lake frontage which has sandy shores and the appearance of crowded public beaches. Sandy beach frontage commonly has twice the value of shores with soft bottoms.

Swimming as a sport does not have a significant intra-activity density limitation except at the crowded public or commercial beach where pollution may build up to more than 1000 *B. coli* per cc., the level considered to be pollutive. The space it consumes is beach and littoral zones. Consequently, there is competition with any other activities which also need this space. Swimming is not significantly damaging to water quality except for possibly some turbidity originating from intense activities. On sandy beaches this is minimal.

The manner and place in which fishing is pursued varies. One can cast with a spinning rod or casting rod, fly-fish on the surface or near the surface, still-fish with cane pole and bobber or drift or anchor over the depths with a weighted line or in some cases troll with a motor.[1] Casting and trolling requires considerable space while dropline fishing does not. The fisherman who is casting will usually work a whole shoreline or bar. His space requirement minimum will be the distance he can cast—about 75 feet and an area of 0.4 acres. But most fishermen will be intolerant of one another at much greater densities. For example, aerial counts of fishermen have shown few densities greater than one boat per 10 acres on lakes (Threinen, 1962). Although lakes may have space to fish and underutilized stocks of fish, intolerance may prevent more fishing. Also a greater division of the crop into smaller take-home amounts may be the cause for loss of interest as indicated by a decline or leveling of angler license sales.[2] The crop of fish available to anglers will not be treated in this discussion.

The fishing activity can be pursued from the shore or from the open water. Shore fishing may in many instances be as important as the open water fishing. Estimates indicate about 25 percent of the public engages in fishing.[3] Fishing is consumptive of both water space and shore space, not only because of fishing space required. We also have a requirement for maintenance of the resource by retention of

[1]Motor trolling is prohibited on most lakes in Wisconsin.

[2]Angler license sales in North Central States have reached a plateau and even declined slightly in some instances rather than follow population growth trends.

[3]The 1960 census of sport fishing indicated 19.8 percent of the public pursued fishing in the East North Central States, an area including Wisconsin-Michigan and more southerly states. In the West North Central States 28.1 percent of the public fished. Wisconsin would have higher participation than areas to the south because of its greater numbers of rural and small town residents and greater water areas.

the spawning and nursery grounds which for most species lie along the shore. Wild shorelines with natural habitat provide the best conditions for the development and growth of a balanced fishery. Fishing faces competition from uses of shoreline that are destructive to critical habitat and surface uses that consume space particularly in shallow water. Also fishing can be damaged by winterkill or deteriorating water conditions which favor carp, conditions caused by pollution and excessive fertilization. The after effects of efforts to improve swimming by control of vegetation with either copper sulphate or sodium arsenite linger as a potential threat to the fishery. Mollusks, one of the important food resources, are eliminated by $CuSO_4$ application[1] and all bottom fauna will be reduced by $NaAsO_2$ (Lawrence, 1958). Fortunately, newer chemicals have the potential for control with less damage.

Boating has many forms, ranging from canoeing and rowing of a small skiff to the fast inboard. Classes would be best described according to the means of propulsion, as sailing, rowing, paddling, displacement motorboating and planing motorboating (fast boating). The latter is combined with swimming for water skiing. Boating is an integral part of many activities such as swimming, sightseeing, fishing and others, but it is nevertheless an activity sufficiently distinct to deserve a special title.

Boating demand is consumptive of shore space and water space, and space consumption on water is directly proportional to speed.[2] Consequently, consumption of the water space is much higher for fast boats and for indiscriminate travel such as is done when water skiing. Frequent turns and much slalom are characteristic of water skiing.

The water ski rig ordinarily has 75 feet of rope for towing plus the length of the boat, a total length of 90 feet. Speeds of about 12 miles per hour are required to achieve the necessary dynamic lift for planing of a skier with his relatively small planing surfaces. Water skiing is the activity of fast boats and it is an activity which keeps them occupied for extended periods. Without water skiing fast boating would find less employment on the small inland waters. Speed is

[1]There is considerable disagreement on this question. The Moyle (1949) review notes that mollusks are poisoned by $CuSO_4$ and its insoluable end product $CuCO_3$ after application to lakes. Specifically $CuCO_3$ is used to control snails, where swimmers itch is encountered. Hasler (1949) reviewed the antibiotic aspects of copper treatment of lakes and questioned the practice. Mackenthun (1952) found differences in the abundance of bottom organisms in treated lakes but concluded the differences were caused by ecological variation. My view is that mollusks coming in contact with $CuSO_4$ in amounts applied for algae control are eliminated but greater quantities of $CuCO_3$ than are usually found in the bottom muds of treated lakes are required to kill mollusks.

[2]This statement might be modified upward and space consumption described as mildly geometrically related. Taking motor vehicles as a parallel example safe separation based on stopping distance rises geometrically. For example, the 20 mph vehicle would travel 67 feet to stop, the 40 mph vehicle 193 feet and the 60 mph vehicle 432 feet according to Wisconsin Motor Vehicle Department figures.

not a very significant element for the transportation of fishermen or for sightseeing because sightseeing is most enjoyed at slower speeds. We have observed that the intensity of motorboating reaches a peak in early summer and declines as the summer wears on. People have had their sightseeing and have learned to get up on a pair of skis, and thereafter the activity dies down.

Aerial surveys and counts of boats have shown that the number of boats on a lake is related to the amount of shore and that a high shore-area ratio results in high concentrations. As a consequence, small lakes have greater densities than large lakes (Fig. 1). The number of boats *in use* for fishing or boating of any kind is much lower than the number *present* on the lake, and a common level of use at a peak activity period is 10 percent of the boats present (Threinen, 1961). Consequently, the parking space for a boat will be an ever-present need. The parking requirement for the average small boat is a space about 5 x 20 feet. The immense requirement for parking space for boats in the littoral zone is manifested in extensive boat docks, harbor and marina facilities which always seem to become filled up.

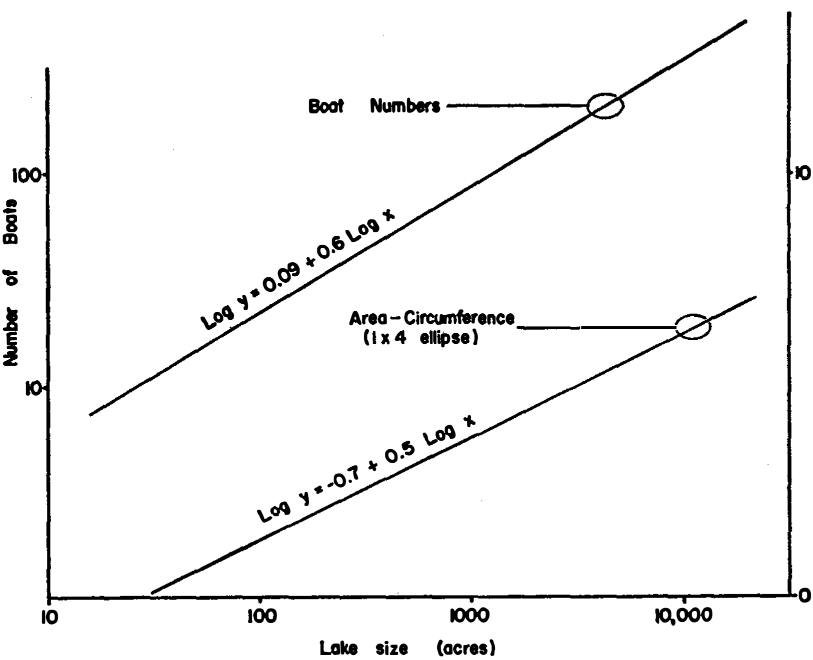

Fig. 1. Relationship between area and boat numbers observed and area and circumference of an ellipsoid lake. The slope of boat numbers—area nearly corresponds to an area—circumference slope. Source: Threinen, 1961.

Even the boat at anchor takes space which otherwise would be used for boating or swimming. The anchored boat will usually have an anchor or mooring line several times the depth of mooring and will, therefore, have an equivalent swing circle which may approximate the width of the average lake shore lot.[1]

The spatial demand on water for recreational boating when done at low speeds causes a negligible amount of intra-activity and inter-activity interference. At fast speeds both intra and interactivity interference arises. Fishermen are driven out of areas in which fast boating takes place. Enactment of laws limiting speeds of water craft in fishing bays, as in Illinois, is ample testimony of the extent of interference. In Wisconsin greater densities of fishing activity occur in the northern part of the state because of lesser amounts of interference. Even slow boating—rowing and paddling—is interfered with and greatly diminished on a body of water dominated by fast boats. The wake waves of fast boats have been a cause of complaint by sail boaters, especially on relatively calm days. Sailboats are diverted and caused to lose the wind. Water skiing is density dependent and when pursued to excess, it limits the number of participants. In frequent aerial counts we find that the density of water skiing seldom builds up to more than about one boat per 20 acres of water. Evidently, as the number builds up an element of fear sets in. The downed water skier, a small object in the water, is not a very secure person as boats speed around him. As a consequence, we have concluded that this amount of area (20 acres) is the minimum spatial requirement of water skiing. Although interference with swimming is almost too obvious to mention, the fast boat traveling at 20 miles per hour has no place among a recreational activity where maximum speed is only two miles an hour. Another aspect of motorboating which has recently been given attention is pollution. Heavy motorboat exhaust discharge results in water contamination in the form of oil film and can affect the flavor of fish flesh. This occurred when boating activity amounted to one gallon of fuel consumption per 300,000 gallons of water (1-acre foot) (Surber, English and McDermott, 1962).

Boating in its many forms is a major activity on water and our best estimates suggest it is sought by 25 percent of the public. In Wisconsin alone boat license sales amount to 240,000—six percent of the population not including manually propelled boats nor out-of-state boats. Many enjoy the use of a sailboat. Sailboats comprise only two percent of the registered boats with the activity concentrated on larger lakes (Threinen, 1962).

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[1]Knight's Modern Seamanship advises a scope of 6x the depth for anchoring lines.

Aquatic life study and observation is probably a select activity including members of Audubon societies, those associated with the fields of aquatic botany or zoology, collectively referred to as limnology. This activity has a relatively low level of participation amounting to less than 5 percent. It feasts on all forms of plant and animal life with the more obvious forms such as flowering plants and birds being most important to the largest number. The natural plant and animal communities are the habitat for this group and it follows that the more wild shore and undisturbed areas the more fruitful will be their "hunting." Many forms of plants and wildlife do not exist in the front yards of homes and cottages.

Hunting and trapping are not the important activities on waters that they were in years past when the supply of waterfowl was greater and shooting season were longer. The capability for hunting is dependent upon the presence of food resources to accommodate the migrating and resident waterfowl and the presence of nesting areas for the resident birds. Nesting areas consist of nonwoody vegetation near water for many species and the marsh edge for others. The wood duck nesting in trees is the principal exception here. Trapping is dependent upon the marsh where the muskrat makes its home.

Waterfowl and fur resources are always an element of the esthetic enjoyment of the water but during the hunting and trapping season they have an additional value. The maintenance of the game and fur resource requires wild conditions. In addition the hunter and trapper must have the space in which to operate. Both activities are low density activities. The demand is fundamentally for shore space, for a place to maintain a blind or the marsh to jump the ducks or trap animals. Many other activities have designs on the same space and these other activities have a high level of participation. The swimming zone that provided a weed-free beach has no food for ducks, and waters rooted up by the boat swinging at anchor leave little or no food for waterfowl. An indication of the space required for duck hunting is available in the blind spacing at the Horicon Marsh where hunters rent blinds. It is 150 to 200 yards between blinds with no consideration for varying quality between sites.

Duck hunting participation has been estimated to be 25 percent of the small game hunters in Wisconsin—a total of 100,000 hunters or 2.5 percent of the population. Only 4,300 trpapers' licenses are sold in the state. Of course it must be remembered that the product of trapping is not consumed by the trapper; it contributes to secondary benefits and therefore has greater value than indicated. Hunting and trapping are fortunately out of phase with other activities because they take place in the fall and winter months. Although they do not seriously interfere with other aquatic activities, destruction of habitat can significantly affect them.

The desire to obtain aquatic recreation is manifested in several different ways: A public recreation facility such as a beach or park, a commercial facility which provides swimming, boating and fishing, or through the means of a privately owned piece of land on which a cottage or home has been built or lastly, over the wild land in either public or private ownership. In these forms the public swimming facility and the commercial facility are very intensive uses of the shoreline and there is little room for fish and wildlife uses of the shore. For example, the fish will not be able to nest in these shallows nor will there be nursery grounds with protecting weed beds for the young fish. The same applies to most other forms of animal life.

With population growth and demand for shore use, a very high percentage of the lake shore will go to the most intensive individual human uses. This level of use calls for a virtually barren shoreline with little remaining for wildlife or esthetic values.

Conversion to cottages and homes, although a low density use, still makes a very high demand on the shore because the individual desires require the weed-free, insect-free swimming beach with low utility for fish, wildlife and esthetics. At this same time, intensive utilization may have an impact on the quality of the water. Too fertile an environment becomes adverse to both the human users and the life harvested and enjoyed by man.

IMPACT ON KEY BIOTA

The impact of man's use of water can be seen through the use of certain symbolic examples. By sketching the life history, value and outcome of these forms of life under conditions imposed by man we should have some idea of how we might wish to visualize the future of inland water resources.

Wild Celery

Wild celery (*Valisneria americana*) is called one of our most valuable aquatic plants by Martin, Zim and Nelson (1951). It grows in the shallows and the tender flexible grassy growth form is especially suited to growth on the sandy bottoms in the littoral. It is most common at depths from 2 to 6 feet and may grow to depths as great as 8 feet (Threinen, 1952). Fertilization usually occurs in August at which time the coiled stamen or pistil ascends to the surface, releasing floating pollen and fertilizing the ovaries. The plant reproduces by means of seeds in pods and vegetatively by means of runners. Food is stored in rhizome and tuber during the dormant period. The root system is shallow and the runners and tubers lie close to the surface. Also the stems and leaves are fragile and easily uprooted. It is a desirable plant in man's scheme because it does not become so dense that it obstructs activity.

Wild celery is a favorite food of waterfowl, especially of the diving waterfowl. It was called "excellent" as a food plant by Martin and Uhler (1951). As the flocks of migratory waterfowl move through Wisconsin waters, they often leave a windrow of the uprooted celery stems and leaves in their wake. Small fish will commonly be seen in association with the beds of celery, although it is not so productive of aquatic organisms as plants with more surface area (Andrews and Hasler, 1942). Carp will often uproot and eat the celery as they grub around in the bottom.

However desirable we may find it to be, wild celery will not survive high shoreline use by people. Its leaves and stems are easily broken and uprooted. This plant was reported to be the most common aquatic plant in Lake Mendota by Rickett (1922). This is true even today but on heavily used shores it is missing now. Littoral areas, formerly solid beds of wild celery, revert to barren sand. Furthermore, it is evidently intolerant of interspecific competition with plankton and epiphytic algae. Lakes downstream from Lake Mendota, Lakes Waubesa and Kegonsa, have none of this species present although the water and bottom conditions are suitable otherwise (Threinen, 1952). Historically, they too had this species in abundance.

Water Lily

The water lily (*Nymphaea odorata*) is a dicotyledon which blossoms in midsummer. The brilliant white blossoms open like summer gems right on the surface of the water where it is subject to pollination from insects. The circular leaves are floating, crowning a buoyant stem, and the group of leaves and blossoms which are the product of one plant form a spreading surface aggregation which if dense will shade out most other plants. The flowering stem recoils after fertilization and seeds mature under water. Reproduction is both sexually by seeds equipped with a floating mechanism (aril) and vegetatively from root stocks or tubers buried in the mud. Thick starchy rootstocks spread out in the soft bottoms of protected bays or shores which are its usual habitat. It grows no deeper than about four feet.

Water lilies are not a common direct food resource for many aquatic invertebrates except certain insects but the leaves and stem are the site for a collection of surface living animals. A common sight is to see a frog perched on a lily pad. The most sage advice to a largemouth bass fisherman is, "Cast among the lily pads." The bass like the shade offered by the leaves. The rootstocks are eaten by muskrats, and snapping turtles have been known to dig them up and eat them.

The water lily will not stand up under any amount of motorboating. If the limited number of leaves and blossoms are cut off, the plant dies. The plant does not grow in firm bottom types either. One could not convert muck shores to sand and still expect water lilies to grow. This esthetic gem, the white water lily, unless protected will not survive under intensive shore uses.

Bullfrog

The croak of a bullfrog is synonymous with the wild aquatic environment. The bullfrog (*Rana catesbiana*) is the largest species of frog found in the United States. Its habitat consists of the marshy shore of the weedy bay of a lake or stream, a situation where it can readily jump from land to water for protection and water to land for feeding. The bullfrog feeds primarliy upon insects but will take all types of animal life. Huge masses of eggs are laid in a thin sheet on the surface during the spring and the tadpoles metamorphose into adults during the third summer according to Knudsen (1958). The first two years of its life is intimately associated with the weeds in the shallows on which the tadpole depends for both food and protection.

The bullfrog is a conspicuous member of the aquatic community by reason of its big size and the distinctive bass voice. Tadpoles convert vegetation to flesh and presumably furnish an important food supply for fish. The adults are food for humans and food for predatory birds and aquatic mammals. Clearly, the animal has esthetic value, is a primary converter and can be a food resource with economic value.

The bullfrog is a product of the marshy shore. Without the circumstances for laying of eggs, rooted or attached vegetation for food and protection of the young and cover for the adults, it will disappear. The improved shoreline with weed-free beaches and mowed grass offer no habitat.

Northern Pike

The northern Pike (*Esox lucius*) is a fish at the peak of the pyramid of numbers in the aquatic environment. The northern pike or its cousin the muskellunge (*Esox masquinongy*) are usually the largest predator fish in Wisconsin's lakes. Their food consists principally of fish which are seized by sudden darts from a hiding place among the weeds. For notes on its life history, we can turn to the work of

Carbine (1942). The fish spawn in the early spring just as the ice goes out. The spawning habitat is ordinarily flooded emergent vegetation—flooded marsh vegetation. As the young fish grow, they turn to progressively larger units of food. Fast growth of the species is characteristic.

As the largest predator fish, northern pike have an important role in keeping less desirable fish from overpopulating an aquatic environment. Lakes that have poor predator populations commonly have stunted panfish populations. These fish are a favorite with anglers and they bite readily.

The specificity of the spawning grounds for the northern pike can cause its undoing. The shores which it desires for spawning grounds are also coveted for improvement and the mooring of boats or the creation of swimming beaches.

Burrowing Mayfly

Discussion of the burrowing mayfly (*Hexagenia limbata*) does not seem very important because after all, it is only an insect—but this is not the case. According to Hunt (1953), the burrowing mayfly is a sensitive organism which cannot withstand oxygen lower than 1 ppm. The mayfly larvae live in the silt bottoms of lakes or streams, burrowing in the surface of the silt where they live upon microscopic plant and animal fragments. Their presence may be told by the existence of the small burrows. For two years in a north temperate climate, they remain in the bottom environment until calm days in June and July when they metamorphose into adults. The mayfly is a common resident of the moderate depths of lakes, the depths above the thermocline where the oxygen does not drop down to too low a level. The emerging adult is best known to fishermen because in the emergence season almost any of the centrarchid species of fish can be caught on a popper. Upon emerging, adults lay their eggs on the surface of the water to renew the cycle and soon die.

The mayfly is an important fish food resource in most of the glacial lakes according to Britt's summary (1962) because it is one of the more abundant larger soft-bodied insects. It is also a significant food for waterfowl (Anderson, 1959) especially the young waterfowl so desperately in need of protein for growth.

Apparently, when the daily respiration cycle for a lake or stream becomes so extreme that oxygen becomes depleted during the night the mayfly, closely tied to the bottom, is a victim. It disappears from waters which are too fertile. The most recent classic example has been the disappearance of the burrowing mayfly in western Lake Erie. It was not a dominant organism in fertile, shallow Lake Winnebaga already during the 1920's (Baker, 1924), and it is seldom seen today. Waste disposal incidental to the use of shore for residences may result in excessive enrichment which can eliminate this important organism. The mayfly thrives in only moderately fertile water but not too fertile an environment. If eliminated, the low-oxygen environment will be assumed by the smaller sized chironomids or blood worms.

Mallard Duck

The mallard duck, a dabbler, makes its home along the shallows of lake, stream or marsh where it can dip for plant or animal foods. Kortwright (1943) gives the best life history resumé. Its principal foods are known to be the seeds and rootstocks of aquatic plants, especially the pondweed, but young birds require much protein in the form of invertebrates as Moyle (1961) points out. Nesting occurs in early spring amid grassy cover near a body of water. After setting for a period of three weeks from eight to ten young are born. The family then begins the rearing process in shallow water where the mother duck with her dutiful fleet of young in tow is a common sight. The family requires the water rearing site and for the young, the presence of escape cover. The rushes, cattails and brush along the shore provide the ideal circumstances.

The value of the mallard and other ducks lies first in their esthetic appeal and secondly for hunting value. The mallard is a favorite of hunters because it grows to good size and is excellent eating. Predators on the eggs and the young are its principal enemies, besides man. Concentrations of ducks can deplete stands of vegetation.

The mallard is dependent upon the nesting cover, escape cover and food resources of shallow water. When these are destroyed, as they would be with the complete disciplining of the shores of a lake, the duck has only some resting area and feeding area left. This ubiquitous species can even prosper in cities provided there is some wild and semi-wild land left for it.

WATER SUPPLY AND ORGANIZATION OF USE

Rather than describe waters in terms of pure supply, such as numbers or acres, it appears preferable to consider their character, thus emphasizing the value and organization of the water resource use. Most of Wisconsin's lakes are natural lakes of glacial origin which range in size from little ponds an acre in area to the huge Great Lakes with millions of acres of water. In addition, there are many impoundments which range in size from one to 23,040 acres. Essentially they all come under the same physical influences brought on by depth and size and location within the prevailing westerlies wind belt.

In very shallow water (less than 4 feet), growth and development of emergent plants is fostered and the lake environment approaches the characteristics of a marsh. Here sorted sandy shorelines are impossible because the wind is incapable of exerting its full force as the products of growth and erosion settle out. Lakes of this type are basically waterfowl habitat and good for neither fish nor other aquatic activities. Substantial improvement of them for broader purposes is difficult if not impossible except through increased water depths by impoundment or dredging.

Submergent aquatic plants in most lakes do not grow in depths greater than 16 feet. Dense growths which can seriously impede water uses are generally confined to less than 12 feet. Therefore, when we speak of "open water" it includes water more than 12 feet deep. Although there are many lakes with less depth with good fish populations, lakes require some open water to avoid winterkill of fish. Shallow lakes which escape the problem have fresh water entering them. For the above reasons the best waters have "open waters."

The lakes in Wisconsin fall into convenient classes as shown in Table 2 (Threinen, 1961). Small ones will be surrounded by bog or marsh because wave action is not violent enough to sort the rain of fine soil particles settling to the bottom. Uusually, these are lakes less than 100 acres and they comprise 70 percent of the 4,138 named lakes in the state. Because of these circumstances, they will not be so desirable for modern recreation without improvement. The medium-sized lakes, those between 100 and 1,000 acres, feel the force of the wind on the windward shores and sorted beaches are available. Twenty-five percent of the lakes fall in this class. Then there are the large lakes over 1,000 acres which have well-sorted shores surrounding the entire basin except for the protected bays and stream estuaries.

TABLE 2. SIZE CLASSES OF WISCONSIN'S NAMED LAKES[1]

	Size Classes	Number of lakes	Frontage Character
Small	0–19	980	Mostly soft bottoms
	20–49	1,241	in littoral
	50–99	783	
Medium	100–499	893	25 percent
	500–999	126	50 foot bottoms in littoral
	1,000–1,999	56	Mostly firm bottoms
Large	2,000–9,000	50	in littoral
	10,000–99,999	6	
Very Large	100,000–199,000[2]	1	All firm bottoms in
	200,000[3]+	2	the littoral
	Total	4,138	

[1] Source: Wisconsin Conservation Department (1958).
[2] This class includes 137,708-acre Lake Winnebago.
[3] This class includes both Lakes Michigan and Superior.

Historically these medium and large lakes with the sorted shores were the first to get the attention of the recreationist building a cottage or a resort or public agency providing a beach. As development took place, a sequence was followed. At first when only the prime shores were built up, there was little interference with esthetic values, and the fish and wildlife based on the wild shore with marsh frontage and soft bottoms. As the supply diminished near the cities, those desiring lake frontage turned to the less valuable shores which were the reservoir for many of the assets around the basins, and they turned to the small lakes.

Some historical review of the use of shores is necessary for an appreciation of the ultimate organization of uses. Clearly the individual would choose first to combine as much of his preferred outdoor living on water with his residential requirements as possible. In the early stages of use a period which can be termed the "estate era," a very extensive use of shore and water took place and the natural assets which have been described were relatively undamaged. Then complete and more intensive use of shoreline evolves because of tax pressures and profit potential on an increasingly scarce commodity. Finally, values and demand become so great that shores are converted to the most intensive forms of use (Fig. 2). Apartments and hotels replace houses, and swimming beaches and marinas replace wild frontage. This form of use is now evolving in areas near the large cities.

ANALYSIS

Water recreation focused mainly on lakes is a package of values that depends on good water quality and subsists on a varied landscape and biota. The resource manager is faced with a task of retaining those values as the pressures on the resource grow. Use of water for recreation cannot take place without some loss of values in some cases, and a substitution of values, one for another. The objective in management, therefore, should be to minimize the losses while effectively trying to provide for uses. What sort of prescription is needed to perform this task?

The pressures of the growing numbers of water recreationists threaten to extinguish the very values sought. As we have seen in this discussion, pressure on the resource, in most of Wisconsin at least, is concentrated in the form of extensive use of the shore for cottage purposes. The amount of the shore that is set aside for truly concentrated public use such as beaches and landings is very limited (less than 5 percent for most counties).[1] If more users are to be ac-

[1]Source: County waters inventories published by the Wisconsin Conservation Department.

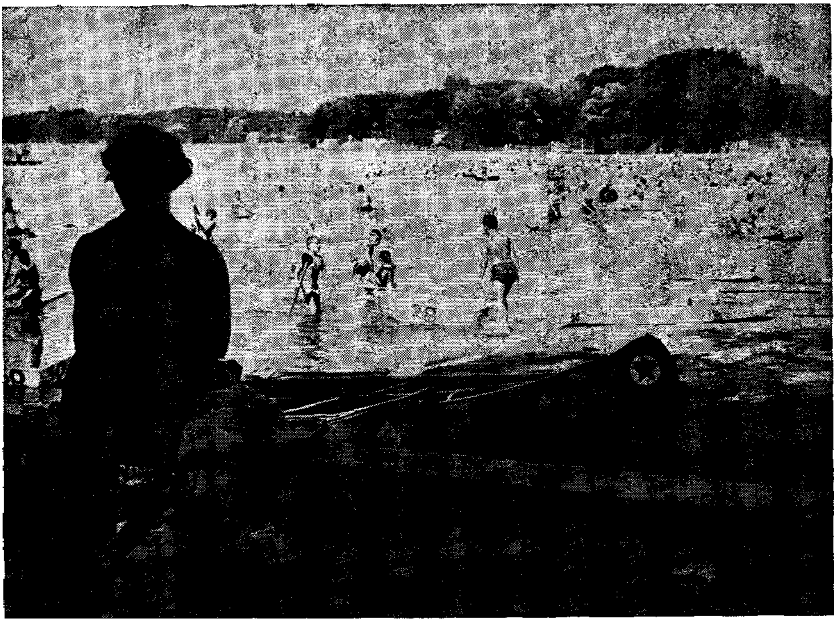

Fig. 2. Intensive use by man, such as pictured, leaves little space for other resource requirements. Unless shoreline use is directed we can expect it all to become dedicated to the most intensive types of use. Browns Lake, Wisconsin.

commodated through the means of cottages and housing on the shores it will be done only at the expense of the frontage that is now unconsciously dedicated to maintaining water quality and preserving esthetic and fish and wildlife values, or through more concentrated use of the shore for buliding sites, or providing areas for intensive use.

It would be best to further concentrate the use of a body of water at certain sites and leave other sites undisturbed in order to protect the values desired. By doing so, we shall maintain opportunities for use by greater numbers.

The physical composition of most of the glacial lakes in Wisconsin provide a clue which should be employed for resource protection. We have seen that on medium-sized lakes about one-fourth of the shore and littoral zone on the lee side tends to be marshy. The evidence regarding uses, values and habitat requirements suggest that it ought to stay that way on lakes of this size and other sizes as well. A wild shore does not contribute to overenrichment as does an occupied shore. One could even go a step further and say that the amount of wild shore should increase with the intensity of use. If 75 percent of the shore has moderate use (*i.e.* cottages) then 25 percent of the shore should be wild land. If 25 percent becomes intensively used then 25 percent should be wild and 50 percent semi-wild.

By paying attention to shore use many water use problems can be avoided. Maintenance of a wild or semi-wild shore will take bold zoning and other land use directive measures. A golf course on the shores that will maintain scenic values, the bullfrog, northern pike and mallard is better than another marina or more urban area which will contribute to the destruction of water quality and resource value. The picnic grounds with woods and semi-wild shores serve more people than row on row of cottages and give more protection to both water quality and other resources. Shore users cannot vent sewage collection systems and septic tanks into natural waters without consequences. The examples of older communities in Europe and lakes in the United States furnish good examples of the dangers and damage resulting from excessive fertilization (Hasler, 1947).

Space on water is not an infinite quantity which can be divided and redivided forever among users. There is a practical limit among all activities each of which is both density dependent within itself and with other activities, if quality is to be upheld. Facilities for swimming, important as that activity is, should not be expanded to usurp all the nursery areas for fish, another important activity. The required anchorages for boats should not usurp the swimming area, and planing boats towing water skiers should not have a monopoly on the water surface.

The opportunity to control at least some of the practical limits of use lies at the shore. Size of the access area, swimming area, the types of shore use and intensity of use have the potential for activity direction. For example, limitation to a walk-in access on a small lake can effectively curtail entry of fast boats. Certainly, the weighing of levels of participation and amount of interference will be vital factors in reaching decisions on water use; however, one must also consider the subtle biotic causes and effects as embodied in the mayfly, wild celery and other examples. Finally, one must consider the aesthetic aspects of water quality and space. Excessive speed in confined conditions is as out-of-place as an ocean liner on a pond. An apartment crowding the shore of a small lake is just as great a violation.

The power latent in the Wisconsin statutes to classify lakes and streams by use should apply to both the shore and the water. What is done on the shore in large measure governs the use and value of the water particularly for the small glacial lakes which dot the Wisconsin landscape.

The geometric rise of water frontage land values will force land ownership and use to destructive levels because few can afford to pay more for their land than their castle. The guiding hand of government is essential to meet these problems.

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IRRADIATION PRESERVATION OF SHELLFISH

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This project was sponsored by the U. S. Atomic Energy Commission, and the results reported here have been collected over a period of several years. During this time many observations have been made which show that both iced and frozen shrimp, and iced oysters can gain some advantages by being subjected to low dose gamma irradiation treatment prior to refrigerated storage.

The application of irradiation for increasing the refrigerated storage life of shellfish has been reported by (Bender, Fields and Lee, 1957), (Mangan, Steinberg, and Carber, 1958), (Procter, *et al.*, 1958), (Brody, 1958), (Gardner and Watts, 1957), (Miyauchi, 1958), and (Novak, 1962, 1963). Most of these studies were made with samples from unknown sources, and usually just a minimum amount of information was available about their age, method of catching, refrigeration temperature prior to treatment, and other factors responsible for determining their keeping qualities after irradiation.

Ionizing radiation is capable of destroying bacteria present in shrimp and oysters, and also the enzymes capable of catalyzing autolysis. However, high irradiation, doses (above 1.0 Mrad) usually cause other chemical changes which alter their flavor and odor sufficiently to render them organoloptically unacceptable. Low dose gamma irradiation (0.15-0.25 Mrad) does not produce a sterile product, but is capable of destroying approximately 85 to 95 percent of the microorganisms present in shellfish. Of importance is that few chemical changes occur, and the unaltered product is organoleptically acceptable after the radiation treatment.

EXPERIMENTAL

Shellfish were irradiated in the irradiator located in the Nuclear Science Center at the Louisiana State University. The high gamma radiation source was a 10,000 curie cobalt 60 irradiator, which was designed specifically for food pasteurization studies.

The absorbed gamma radiation dose was measured by Fricke Dosimetry. Gamma radiation is measured in this method in the range of 0.2×10^4 to 4×10^4 rads by oxidation of ferrous ammonium sulfate and determination of the ferric ion spectrophotometrically.

The investigators supervised all handling of shellfish from the time they were removed from the water until they were transported to the laboratory. Procedures employed for obtaining fresh shellfish, the method of handling and storing, and the time of holding prior to irradiation, are factors involved in ascertaining the keeping qualities after irradiation.

Organoleptic scores for judging sensory differences in the attributes of irradiated shrimp were based upon odor, general appearance, sweetness (for shrimp), flavor and texture. A definite or strong degree of changed attribute was sufficient reason to consider any product as being unacceptable for commercial trade outlets.

The 10-point scale employed for judging sensory differences in the flavor of irradiated fishery products was recommended by the participants of the A.E.C. food irradiation program.

Chemical and bacteriological tests were performed on most samples, and included indole, trimethylamine, ammonia, picric acid, pH, bacterial and black spot counts. Gas chromatography was used to study the changes that occurred during irradiation in the fatty acids, nitrogen compounds, and carbonyls. Organisms resistant to the low dose radiation were isolated and changes produced by various radiation levels were investigated. Summaries of these results are included in this paper.

IRRADIATION OF SHRIMP

Samples for valid comparisons were processed from the same batch. Variations in fishing areas, weather conditions, purity of wash waters, ice and containers, and the cleanliness on boats cause considerable

TABLE 1. A COMPARISON OF ORGANOLEPTIC SCORES ON NON-IRRADIATED AND IRRADIATED (150,000 RADS) ICE STORED, RAW, SHELL ON, SHRIMP (IRRADIATED 72 HOURS AFTER CATCHING)

Sample Treatment	Score after Listed Storage Period			
	Initial	14 Days	21 Days	28 Days
Frozen Control	8.6	7.4	6.0	5.2
Irradiated	8.6	7.7	6.5	5.8
Non-Irradiated	8.6	4.9	Spoiled	Spoiled

Ratings are Averages for 25 Individuals
Values are averages for participants on taste panel for the attributes of odor, appearance, sweetness, flavor and texture.

initial differences in shrimp for each experiment. Unless all treatments are from the same batch, comparisons are difficult.

Since commercial use is the ultimate goal of this work, procedures were selected which could be employed for large scale handling and distribution of the product.

Numerous experiments were performed to determine the manner in which fresh shrimp must be handled, how long they can be held and still irradiated successfully, what packaging materials should be used, and the best methods of handling and storing after irradiation. The following experiments are typical of several hundred trials. Many tests were run in inland cities to determine if people in these areas would accept and purchase the superior irradiated products.

EXPERIMENTAL

Fresh shrimp were caught in the Gulf of Mexico, washed aboard the trawler, and taken to the laboratory in Baton Rouge. They were intentionally held packed in ice for three days. All of the shrimp were washed again, packed in Mylar bags and separated into two parts. One was employed as the control, and the other was subjected to a gamma radiation dose of 0.15 Mrad. All of the shrimp were packed and maintained in crushed ice. The samples were appraised organoleptically after two, three and four weeks. Results are given in Table 1.

Score	*Flavor Judgement*	*Comparative Characteristics*
10	Excellent	*No change* from the flavor of fresh or frozen products of similar species of highest quality,
9	—	*Loss of normal flavor components* in part but not distinguished consistently by new or changed flavor characteristics.
8	Very good	*First noticeable change of* flavor: development of such flavor changes is con-

		sistently apparent but degree of flavor change is slight.
6	Good	*Moderate degree of changed flavors*: distinguished from score 8 by an increasd intensity (quantitative change) or occurance of additional changed flavor (qualitative change) not previously noted.
4	Fair	*Definite or strong degree of changed flavors* distinguished from previous levels by the fact that such flavor change is now so definite that any abnormal components become dominant in contrast to normal flavor components. At this score and lower scores the loss in palatability becomes apparent even in difference tests.
2	Poor	*Extreme degree of changed flavors* such that reaction is one of saturation in recognizable components of flavor change; usually considered end point of any objectionable flavor development in that panel resistant to judge samples of any greater intensity.
0	—	*Unable to evaluate*: if flavor change has progressed through the scale, the panel will place samples in this category on basis of visual and odor examination and will be reluctant to taste because of high level of odor intensity placing the sample clearly outside the level of reasonable comparison.

Forty pounds of white shrimp were purchased from commericial shrimpers at Golden Meadow, Louisiana. All of the shrimp which we obtained were caught within 72 hours of the purchase time, and were from the Gulf of Mexico.

The shrimp were packed in layers of ice in Arctic hampers, and transported to Baton Rouge, Louisiana. Within four hours, they were headed, and washed in cold running water. Some were peeled and deveined, and cooked in boiling water containing 0.5% sodium chloride, for four minutes. The shrimp were cooled and packed into Mylar bags (12 ounces per bag). Half of the bags were irradiated at a dose of 150,000 Rads, and then all of the bags were packed in layers of crushed ice, and maintained until removed for sampling purposes. It can be assumed that the shrimp were irradiated within 72 hours after catching. For comparative purposes, another part of the catch (unshelled) was packaged and irradiated at a dose of 0.15 Mrad, and packed into crushed ice.

Organoleptic tests were made on the initial samples, after 14, 24 and 30 days. Non-irradiated packs which were treated in a similar manner were employed as controls. An uncooked frozen control was also tested.

The results are presented in Table 2. Low dose radiation pasteurization did not offer much advantage for cooked shrimp. Holding the cooked product resulted in too much loss of flavor during iced storage. This verifies previous results and also shows that unshelled shrimp which were irradiated, have superior keeping qualities as compared to cooked and irradiated shrimp for the same batch.

Since the cooked shrimp seem to lose much of their moisture content, and this factor could influence flavor, cooked shrimp which are coated prior to irradiation will be tested.

Fifty pounds of washed, headed white shrimp were purchased from commercial packers at New Orleans, Louisiana. They were caught within 72 hours of the purchase time, and were from deep waters of the Gulf of Mexico.

The shrimp were packed in crushed ice and transported to the L.S.U. laboratories in Baton Rouge. They were again washed and divided into the following treatments: frozen control; ice stored non-irradiated; ice stored irradiated; shelled and cooked, non-irradiated; and shelled and cooked, and irradiated.

All of the shrimp were packed into Mylar bags (approximately 12 ounces per bag) and heat sealed. All of the samples which were

TABLE 2. A COMPARISON OF ORGANOLEPTIC SCORES ON NON-IRRADIATED AND IRRADIATED (150,000 RADS) ICE STORED COOKED SHRIMP (SHELLED AND DEVEINED), AND RAW SHRIMP (UNSHELLED)

Sample Treatment	Score after Listed Storage Period			
	Initial	14 Days	24 Days	30 Days
Frozen Control	9.3	7.6	6.7	5.2
Irradiated, Cooked	8.9	7.3	5.8	3.9
Non-Irradiated, Cooked	8.7	6.7	4.7	2.8
Irradiated, Raw, Unshelled	9.3	8.4	7.5	6.0
Non-Irradiated, Raw, Unshelled	9.2	5.3	Spoiled	Spoiled

Ratings are Averages for 20 Individuals
Values are averages for participants on taste panel for the attributes of odor, appearance, sweetness, flavor and texture.

TABLE 3. A COMPARISON OF ORGANOLEPTIC SCORES ON NON-IRRADIATED AND IRRADIATED (150,000 RADS) ICE STORED SHRIMP (SHELL ON)

Sample Treatment	Score after Listed Storage Period			
	Initial	14 Days	24 Days	30 Days
Frozen Control	9.6	7.8	6.9	5.7
Irradiated	9.6	8.4	7.8	6.0
Non-Irradiated	9.6	4.7	Spoiled	

Ratings are Averages for 35 Individuals
Values are averages for participants on taste panel for the attributes of odor, appearance, sweetness, flavor and texture.

subjected to gamma irradiation were so processed within 90 hours after catching. The dose employed was 0.15 Mrad.

Organoleptic tests were made on the initial samples, after 14, 24, and 30 days. The results are presented in Tables 3 and 4.

In the course of these investigations we have been in contact with quite a large number of shrimpers. This has given us the opportunity to explain the necessity for proper handling on the boats, and to encourage them to clean the shrimp and ice them down as rapidly as possible after catching. Much improvement has been observed after two years, and it is our contention that this has been a real service to the industry.

This overall A.E.C. food irradiation program has probably given many chemists, microbiologists, biologists, and engineers the opportunity to get out into the food industries where their services are so urgently needed, and to make and recommend many improvements which should not go unrecognized.

The following field trials were performed in December 1963. The weather was extremely cold and no problems were involved in maintaining the temperature at 32-34° F.

Irradiated shrimp were field tested in both coastal and inland cities, including Tampa and St. Petersburg, Florida, Lafayette, Indiana and Louisville, Kentucky. This enabled us to get comparative results from various areas and to ascertain whether or not our local

TABLE 4. A COMPARISON OF ORGANOLEPTIC SCORES ON NON-IRRADIATED AND IRRADIATED (150,000 RADS) ICE STORED SHRIMP (SHELLED AND COOKED)

Sample Treatment	Score after Listed Storage Period			
	Initial	14 Days	24 Days	30 Days
Frozen Control	9.6	7.8	6.9	5.7
Cooked, Non-Irradiated	8.8	6.4	5.1*	4.5*
Cooked, Irradiated	8.8	7.5	6.0*	5.6*

Ratings are Averages for 35 Individuals
Values are averages for participants on taste panel for the attributes of odor, appearance, sweetness, flavor and texture.
* Note: Cooked shrimp lose much of their flavor within a short period after cooking, but apparently retain this altered state for a long period as compared to raw, unshelled shrimp stored in ice. Notice the slight change between 24 and 30 days.

TABLE 5. A COMPARISON OF ORGANOLEPTIC SCORES ON NON-IRRADIATED AND IRRADIATED (150,000 RADS) ICE STORED SHRIMP (SHELL ON)

Sample Treatment	Score after Listed Storage Period	
	Initial	25 Days
Frozen Control	9.8	5.8
Irradiated	9.8	7.3
Non-Irradiated	9.8	Spoiled

Ratings are Averages for 124 Individuals
Values are averages for participants on taste panel for the attributes of odor, appearance, sweetness, flavor and texture.

organoleptic measurements were similar to those obtained elsewhere on the same products.

One hundred pounds of washed, headed white shrimp were purchased from commercial packers at Golden Meadow and New Orleans, Louisiana. They were caught within 30 hours of the purchase time, and were from deep waters of the Gulf of Mexico.

The shrimp were packed in crushed ice and transported to the L.S.U. laboratories in Baton Rouge. They were again washed and divided into the following treatments: frozen control; ice stored non-irradiated; and ice stored irradiated.

All of the shrimp were packed into Mylar bags (approximately 5 pounds per bag) and heat sealed. All of the samples which were subjected to gamma irradiation were so processed within 36 hours after catching. The dose employed was 0.15 Mrad.

Organoleptic tests were made on the initial samples and after 25 days. The results are presented in Table 5.

Results obtained in all areas were reasonably identical, and therefore have been combined into one table. It can be concluded that iced shrimp will last an additional 10 days or longer when subjected to gamma irradiation with cobalt 60 (0.15 Mrad), and then stored and shipped in crushed ice.

RADIATION-RESISTANT MICROORGANISMS

The morphology and metabolism of radiation-resistant bacteria isolated from shrimp were studied to ascertain if radiation (100,000 rad) altered their characteristics. Radiation-induced differences were observed in optimum incubation temperature, morphology, chromogenesis, carbohydrate utilization, and action on litmus milk. Radiation lowered the optimum temperature of several organisms 12-15° C. Since shellfish are usually preserved under refrigeration, growth of these organisms at lower temperatures could cause a problem, and is being investigated.

Since the production of indole has been employed as an index of spoilage, it was interesting to find that none of the radiation-resistant organisms produced this compound. The negative indole tests correlated with organoleptic acceptance of the radiated shrimp after four weeks storage. This emphasizes the role of radiation in eliminating most of the microorganisms responsible for rapid decomposition.

The metabolism in radiation-resistant microorganisms can be altered by low-dose radiation. In processing shrimp, the development of chemical and physical methods which inhibit these changes may be necessary if they are found to increase the spoilage rate. In conjunction with radiation, such processes could increase the storage life.

RADIATION CHANGES IN FLAVOR COMPONENTS

Volatile fatty acids were isolated from samples of radiated and non-radiated fresh gulf shrimp, and compared by gas-liquid chromatography. Acids found included formic, acetic, propionic, butyric, valeric, caproic, myristic, palmitic, stearic, arachidic, N-hehenic, and isohehenic. Results showed that both samples contained the same acid fractions C_1-C_6 and C_{14}-C_{22} and their isomers, and were present in almost exact qualitative and quantitative relationships with the exception of C_{20} and C_{22}. The concentration of C_{20} was lower, and that of C_{22} was higher in the radiated samples.

Carbonyl compounds were present in both the radiated and nonradiated samples, and included acetaldehyde, propionaldehyde, isobutyraldehyde, N-butyraldehyde, 2-methyl-1-pentaldehyde, 2-4-pentadienal, 2-4-pentadione, 2-hexanal, 2-octanal, citronellal, and acetone. Acetone was present only in the non-irradiated samples. There were no other qualitative differences. Slight quantitative changes were produced by radiation.

Amino compounds identified were trimethylamine, ammonia, methylamine, ethylamine, propylamine, and butylamine. Changes in the radiated samples were a reduction of trimethylamine and ammonia, and an increase in the methylamine content.

IRRADIATION PASTEURIZATION OF SHRIMP
SUMMARY

Low dose irradiation of shrimp with Cobalt 60 results in an extension of their iced storage life of 10 days or longer than non-irradiated shrimp from the same catch. When shrimp are caught under supervision and irradiated within 12 hours, the storage period can be extended for an additional week. Some shrimp tested were purchased off of commercial boats, and experiments have shown that large scale radiation is feasible, even when the shrimp are held iced for 3-4 days prior to irradiation.

After two weeks, irradiated, iced stored raw shrimp, were superior to the non-irradiated product as shown by chemical and bacteriological tests, and organoleptic attributes used to evaluate quality and acceptability. Cooked shrimp which were irradiated and iced stored retained their quality for a shorter period. Studies included the identification of flavor components, enzyme systems, and the nature of radiation resistant microorganisms. A dose of 0.15 Mrad gave maximum protection without any undesirable chemical or physical changes. Higher doses resulted in the development of off flavors. Black spot was virtually eliminated by irradiation.

Both raw and cooked shrimp stored at 38-40 °F. after irradiation do not have the keeping qualities comparable to those irradiated and stored in ice. Canned shrimp were irradiated, but the flavor and texture are altered unfavorably during commercial processing, and no advantages are gained by irradiation.

It must be emphasized that the procedures employed for obtaining fresh shrimp, the method of handling and storing, and the time of holding prior to irradiation, are factors involved in ascertaining the keeping qualities after irradiation.

IRRADIATION OF OYSTERS

The oysters used in these experiments were treated as follows: Freshly shucked oysters, which had been brought in from the oyster beds the previous night, were washed in running tap water (50 °F.) for two minutes, and allowed to drain for five minutes. All draining was done on FDA approved stainless steel skimmers, which had an area of not less than 300 square inches per gallon of oysters, drained, and which had perforations of at least ¼ inch in diameter located not more than 1-¼ inches apart. The oysters were distributed evenly over the draining surface of the skimmer but were not otherwise agitated during the draining period. After the oysters were washed and drained, they were packed into pint cans and stored in crushed ice. Within six hours, twenty-four pint cans were subjected to gamma irradiation (0.2 Mrad) in the Nuclear Science Center in the Louisiana State University campus. After irradiation, they were stored in crushed ice, along with an equal number on non-irradiated pints of oysters which were employed as controls. All of the oysters were tested raw, in contrast to the shrimp, which were boiled for five minutes in water containing 0.5 percent sodium chloride. Fried oysters were hard to score because of the added constituents, and therefore this product was rejected for these tests.

TABLE 6. ORGANOLEPTIC SCORES OF IRRADIATED (0.2 MRAD) AND NON-IRRADIATED ICE STORED OYSTERS

Sample Treatment	Score after Listed Storage Period			
	Initial	7 Days	14 Days	21 Days
Non-Irradiated	9.6	6.0	3.8	Spoiled
Irradiated	9.5	8.0	6.5	5.3

Values are averages for 25 participants on taste panel for the attributes of odor, appearance, sweetness, flavor and texture.

Typical organoleptic results are presented in Table 6.

Similar results were obtained with other batches of oysters treated and tested in the same manner.

IRRADIATION OF OYSTERS
SUMMARY

Many problems have plagued the oyster packers during the past five years. One of the most severe has been from the rejection by state health departments of oysters held in transit for extra days while being shipped from one growing and packing area to another and then being repacked before final shipment to the ultimate distributor and consumer.

Although the excessive bacterial counts might not have posed an actual health hazard, they were above the counts allowed in the standards. Most rejected samples could have been retained as acceptable if some simple method would have been available to reduce the original bacterial counts in the oysters to afford them a few days of extension of quality which would be required for such operations.

Based upon exploratory investigations on gamma radiation of fresh gulf oysters, it would appear that such treatment of oysters can provide advantages for the fisherman, processor, distributor and consumer. If such a method of processing were developed to successful commercial application, fresh oysters could be made available to consumers who presently are able to obtain only the canned or frozen product. Market prices of oysters, presently subject to fluctuations due to overabundances or scarcity, would tend to be stabilized.

Low dose gamma irradiation of oysters with Cobalt 60 results in an extension of their storage life of five days or longer than non-irradiated oysters from the same batch. When the oysters were shucked under supervision and irradiated within six hours the storage period can be extended for several days longer.

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DEMERSAL FISHES AND FISHERIES OF THE NORTHEASTERN PACIFIC OCEAN

A. T. PRUTER

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"To meet the vast needs of an expanding population, the bounty of the sea must be made more available. Within two decades our own nation will require over one million more tons of seafood than we now harvest."

These words were spoken by John F. Kennedy in a message to the Congress of the United States in March 1961. They illustrate one of the most critical problems facing us today; namely, how will the protein needs of expanding world populations be met?

Unfortunately, the old concept that the seas hold inexhaustible resources has long since been proven false. Nations such as Japan and the U.S.S.R. which have substantially increased their production of fish and shellfish in recent years have been able to do so only by sending their fishing fleets farther and farther away from home waters. Their search for new resources has led them to all the major oceans of the world.

Arrival of large Soviet and Japanese fleets in the eastern Bering Sea and in the Gulf of Alaska (Figure 1) has brought them into direct competition with our own fishermen. Expansion of Soviet and Japanese fisheries southward into waters off Washington, Oregon, and even California appears to be just a matter of time and economics.

In the eastern Bering Sea and in the Gulf of Alaska most demersal fishes such as flounders, rockfish, and cods being harvested by Japan-

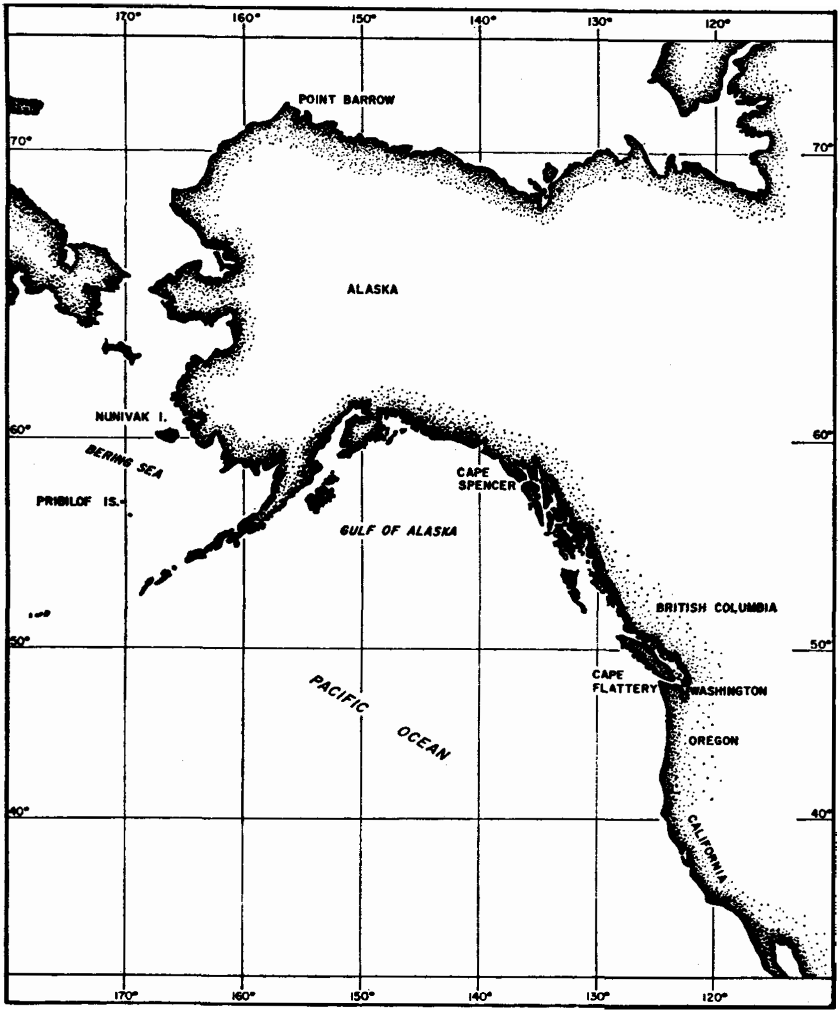

Fig. 1. Northeastern Pacific Ocean.

ese and Soviet fishermen have been subject to little or no previous exploitation by United States fishermen. However, these resources could assume future importance to the United States as a source of protein to feed our expanding population.

In order to evaluate the effect of domestic and foreign fisheries upon the living resources of the northeastern Pacific Ocean we need to know: (1) the characteristics of present domestic and foreign commercial fisheries such as areas of operations and sizes of catches; (2) the temporal, bathymetric, and geographic distributions of demersal fish communities; (3) the magnitude of demersal fish resources available in different regions and depths; and (4) the probable yields the resources could contribute at optimum harvest levels. Without this information we cannot intelligently determine how important these resources may be to our own future well-being.

The object of this paper is (1) to make a cursory review of what we now know about existing commercial fisheries and (2) to assess the extent of demersal fish resources available along the Pacific coast of North America between Oregon and the Bering Sea. The resource assessment is taken from a paper by Alverson, Pruter, and Ronholt (1964) and is based upon information collected by U. S. Bureau of Commercial Fisheries surveys which have taken place since 1940, and upon surveys by the International Pacific Halibut Commission during the period 1961-1963. Catches from over 2,600 individual hauls on the ocean bottom with trawl nets have been analyzed in making the evaluation. Although this represents a vast amount of data, we need to do much more survey work in the northeastern Pacific, particularly in waters off British Columbia, southeastern Alaska, and in the Bering Sea before refined estimates of the demersal fish resources available in these waters can be made.

EXISTING FISHERIES

United States and Canadian

Present United States and Canadian commercial fisheries for demersal fishes in the northeastern Pacific are those using otter trawl gear (nets dragged along the ocean bottom) to harvest a variety of species including flounders, rockfishes, and cods, and those utilizing setline gear (hook and line) to harvest halibut and less important species such as sablefish and lingcod.

Major otter trawl fishing grounds for United States vessels are located off California, Oregon, Washington, and British Columbia, while those for Canadian trawl vessels lie almost entirely off British Columbia. Most of the halibut harvested by United States and Canadian setline fishermen are taken in waters off British Columbia, in the Gulf of Alaska, and in the Bering Sea. The Pacific halibut fishery is unique in that it is jointly managed by the United States and Canada under terms of a conservation convention first signed in 1923 and modified several times in later years. Fishermen of both the United States and Canada participate in the harvest according to annual catch quotas set by the International Pacific Halibut Commission. A hook and line fishery by United States nationals for Pacific cod in the Bering Sea and in the Gulf of Alaska reached substantial proportions around the start of this century but declined to a low level by 1933 and was discontinued during the early 1950's.

United States and Canadian vessels operating in the otter trawl fishery range from about 50 to 90 feet in length and carry crews of two to five men. Halibut vessels are of the same general size range but carry up to nine men. In recent years approximately 130 million pounds of demersal fish (exclusive of hailbut) have been harvested annually by United States and Canadian fishermen in the northeastern Pacific. United States fishermen have accounted for about three-fourths of this total. Recent United States and Canadian production of Pacific halibut has averaged about 70 million pounds per year. The actual share of the total Pacific coast catch of halibut landed by United States fishermen has declined from a level of over 80 per cent in the years 1932-33 to only a little over 50 per cent in recent years.

Current United States fisheries for demersal fishes in the northeastern Pacific may be described as utilizing relatively small vessels of limited range and limited fish-carrying capacity. Most of the vessels are at least 15 years old and many of the halibut schooners are over 30 years old. Present United States harvest of all species of demersal fishes from waters of the northeastern Pacific amounts to about 150 million pounds annually.

Japan and U.S.S.R.

Japanese fishing trawlers began exploring the eastern Bering Sea in 1929. From 1933 through 1937 and in 1940 and 1941 a limited trawl fishery was developed. The Japanese recommenced trawling in the eastern Bering Sea in 1954. As with the pre-war fishery, catches were mainly processed into fish meal although some flounders were frozen and returned to Japan for human consumption. Since inception of the postwar fishery the Japanese have expanded their operations rapidly, and in 1961 they operated 10 large motherships and 173 catcher trawlers whose production was estimated at 1¼ billion pounds of demersal fishes.

Japanese trawlers used in the Bering Sea range from 90 to 250 feet in length. Large motherships of up to 12,000 tons displacement are used to support the trawl fleets. The motherships can process up to 600 tons of fish per day into fish meal. Most of the Japanese catch of demersal fish in the northeastern Pacific is taken in the eastern Bering Sea from the north side of the Alaska Peninsula to south of Nunivak Island. However, in 1963 Japan launched a trawl and bottom gillnet fishery for demersal fish in the Gulf of Alaska.

The Soviets began explorations in the Bering Sea in the early 1930's and resumed them in 1958. Full-scale Soviet commercial operations in the Bering Sea commenced in 1959. Recent catches of demersal fish by Soviet vessels in the Bering Sea are estimated at approximately one-half billion pounds annually. Soviet trawlers used in the Bering Sea range from 120 to 270 feet in length and are supported by a wide variety of vessels including large tugs, refrigerated cargo ships, and oilers. Fleet size has been estimated at between 50 and 200 vessels. The area of operations of Soviet trawlers in the Bering Sea generally is somewhat north of that of the Japanese and in recent years has included grounds northwest of the Pribilof Islands. Since 1962 large Soviet trawl fleets have been fishing in the Gulf of Alaska and their exploratory vsesels have been sighted as far south as off the Oregon coast.

Combined Japanese and Soviet demersal fish catches in the Bering Sea and in the Gulf of Alaska are estimated to be in the neighborhood of 1.5 to 2 billion pounds annually in recent years—some 8 to 10 times as large as demersal fish catches by United States and Canadian nationals from the entire northeastern Pacific. Removals of demersal fish from the eastern Bering Sea by Japan and the U.S.S.R. since 1958 exceed the total combined landings of the United States and Canadian Pacific coast trawl fishery since its inception in the late 1800's.

DEMERSAL FISH RESOURCES

The magnitude of standing crops of demersal fish depends upon the densities of the populations present and upon the extent of habitable ocean bottom available to them. Given equal densities, the size of the standing crops present will be directly proportional to the extent of bottom area available. We know, of course, that population density is not uniform from one region to another, but in fact varies according to whether oceanographic factors are favorable or unfavorable to survival, whether food is abundant or scarce, and whether the bottom substrate is composed of rocks, sand, mud, or silt. For the moment, however, let us disregard these factors and consider just the amount of ocean bottom from the shoreline out to a depth of 300 fathoms that exists in different regions of the northeastern Pacific. This depth range was chosen for comparison since it encompasses the range in which most commercial fisheries for demersal fish now occur.

Approximately 169 million surface acres of bottom area from the shoreline to a depth of 300 fathoms occur between southern Oregon and the eastern Bering Sea (Table 1). Eighty million acres, or almost one-half of this total, lie in the eastern Bering Sea. Fifty-five million

TABLE 1. MILLIONS OF SURFACE ACRES OF CONTINENTAL SHELF AND UPPER CONTINENTAL SLOPE AREA FOR INDICATED REGIONS IN THE NORTHEASTERN PACIFIC OCEAN

Region	Continental shelf (1–99 fathoms)	Upper continental slope (100–300 fathoms)	Total
Oregon-Washington[1]	6	2	8
British Columbia-southeastern Alaska[2]	18	8	26
Gulf of Alaska[3]	45	10	55
Eastern Bering Sea[4]	77	3	80
TOTAL	146	23	169

[1] California-Oregon border to Cape Flattery, Washington
[2] Cape Flattery, Washington to Cape Spencer, Alaska
[3] Cape Spencer, Alaska to Unimak Pass, Alaska
[4] South and east of a line drawn from Pribilof Islands to northern tip of Nunivak Island

acres, or almost one-third of the total, occur in the Gulf of Alaska. In both these regions, which together account for about 80 per cent of the total available bottom area north of California to a depth of 300 fathoms, the only present United States fishery of appreciable size for demersal fish is our setline fishery for halibut. The United States setline catch of halibut from these two regions has amounted to a little over 20 million pounds annually in recent years. Recent combined United States and Canadian setline catches of halibut from these regions has amounted to only 40 million pounds annually. In contrast, combined demersal fish catches by Japan and U.S.S.R. in these regions have been estimated at between 1.5 and 2 billion pounds annually.

The pounds of individual species of demersal fish present per unit area of ocean bottom in each region have been determined by multiplying the pounds of fish caught per hour of trawling by the amount of ocean bottom swept by the net during a one-hour drag. The average sweep (horizontal distance across mouth of net) of the trawls used in the surveys was 40 feet, and the average trawling speed was 2.65 knots. The trawl thus covered approximately 0.018 square nautical miles during a one-hour haul. Size of standing crops was estimated by multiplying the number of 0.018 square mile units contained in particular regions and depth intervals by the average catch in pounds per hour trawling obtained in those regions and depth intervals. These estimates are, admittedly, crude, and their validity rests on many assumptions, including: (1) All demersal fish (within the range of sizes retained) in the path of the nets to a height of 6 feet above the ocean floor were captured. (2) Characteristics of demersal fish communities and of their relative densities on the many grounds on which, because of their rocky or uneven nature, the trawls could not be fished, were similar to those on grounds that were fishable. (3) The trawl sweep or bridles did not tend to herd and thus concentrate

TABLE 2. ESTIMATED WEIGHTS OF STANDING CROPS (ALL DEMERSAL FISH SPECIES) IN BILLIONS OF POUNDS FOR INDICATED REGIONS IN THE NORTHEASTERN PACIFIC OCEAN

Region	Continental shelf (1–99 fathoms)	Upper continental slope (100–300 fathoms)	Total
Oregon-Washington	0.4	0.4	0.8
British Columbia-southeastern Alaska	1.9	0.9	2.8
Gulf of Alaska	2.3	1.1	3.4
Eastern Bering Sea	11.4	0.4	11.8
TOTAL	16.0	2.8	18.8

fish in the path of the net. Obviously, all of these assumptions are in error to varying degrees. Considering the many factors involved, the estimates should be viewed as being minimal and at best as first approximations subject to revision as more complete and systematic data becomes available in the future.

Using the procedures outlined above, standing crop estimates were made for the various designated regions (Table 2). Approximately 18.8 billion pounds of demersal fish (all species) are indicated as occurring between southern Oregon and the eastern Bering Sea. Of this total, 11.8 billion pounds, or almost two-thirds occur in the eastern Bering Sea. Approximately one-half of the remaining 7 billion pounds occurs in the Gulf of Alaska. A comparatively small amount of 3.6 billion pounds is estimated for the area between southern Oregon and southeastern Alaska, the only regions where a United States commercial trawl fishery now occurs.

Standing crops of selected important groups of species are shown in Table 3 for the different regions. Approximately 7.5 billion pounds of flounders, or almost three-fourths of the total flounder population available in all regions, are indicated as occurring in the eastern Bering Sea. The flounder population alone in the eastern Bering Sea exceeds by a considerable margin the entire demersal fish population in all other regions studied. The largest standing crop of rockfish is indicated as occurring off British Columbia and southeastern Alaska; however, reliable estimates of rockfish populations in the eastern Bering Sea are not available due to inadequate United States

TABLE 3. ESTIMATED WEIGHTS IN BILLIONS OF POUNDS OF STANDING CROPS OF FLOUNDERS, ROCKFISH, AND COD AND POLLOCK FOR INDICATED REGIONS IN THE NORTHEASTERN PACIFIC OCEAN

Species group	Oregon-Washington	British Columbia-S. E. Alaska	Gulf of Alaska	Eastern Bering Sea	Total
Flounders	0.2	0.6	1.8	7.5	10.1
Rockfish	0.2	1.0	0.4	+	1.6+
Cod and pollock	+	0.8	2.9	1.5	5.2+

exploratory surveys there in the relatively deep waters which rockfish inhabit. Both the Japanese and Soviets are known to be harvesting substantial amounts of rockfish in the Bering Sea. Rockfish populations shown for other regions, as well as pollock populations in all regions, undoubtedly are underestimated since these groups of fishes are known to be distributed both on the ocean bottom and at considerable distances above it. The standard trawl net used in the surveys had an average vertical opening across the mouth of 6 feet; thus, those portions of the rockfish and pollock populations occurring more than 6 feet above the ocean bottom were not sampled.

Present Resource Use

Utilization of demersal fish resources may be evaluated both from the standpoint of total removals and from the standpoint of their rate of use per unit area of ocean bottom from which they are cropped. Average removals per acre of ocean bottom per year are shown in Table 4 for all regions except the Gulf of Alaska. No meaningful value can be given for the Gulf of Alaska region since the magnitude of present Soviet catches there is unknown.

The indicated production of 18 pounds of demersal fish per acre per year in the eastern Bering Sea is from four to six times the current harvest rate in the Oregon-Washington and British Columbia-southeastern Alaska regions. It is also considerably higher than that shown by Graham and Edwards (1962) for major commercial fishing banks in the northwest Atlantic, including the famous Grand Bank, Nova Scotia grounds, Gulf of Maine and Middle Atlantic grounds, which range from 7.7 to 12.7 pounds per acre per year. The eastern Bering Sea harvest level also exceeds those for well-known European grounds, except the Icelandic Banks which produce 29 pounds per acre per year (ibid.).

Grounds off Oregon, Washington, British Columbia, and southeastern Alaska which now are fished only by United States and Canadian nationals are capable of providing considerably greater than present yields of demersal fish (other than halibut). A significant proportion of the present United States and Canadian trawl catches is discarded at sea for lack of markets. Other species which occur on

TABLE 4. ESTIMATED POUNDS OF DEMERSAL FISH CAUGHT PER SURFACE ACRE PER YEAR FOR INDICATED REGIONS IN THE NORTHEASTERN PACIFIC OCEAN.

Region	Pounds per acre
Oregon-Washington	4.5
British Columbia-southeastern Alaska	3.0
Eastern Bering Sea	18.0

grounds not presently fished could be harvested if a market for them existed.

An estimate of the potential sustainable yield of all species of demersal fish from all waters of the northeastern Pacific can be made using the yield rates for long-fished northwest Atlantic and European grounds. Observed rates for these grounds suggest northeastern Pacific grounds are capable of providing between 10 and 20 pounds per acre per year on a sustained basis. Using a mid-value of 15 pounds per acre per year as the best estimate, this means that the northeastern Pacific grounds should be capable of providing a total annual yield of about 2.5 billion pounds.

As mentioned earlier, Japanese and Soviet fleets now are catching over 1.5 billion pounds annually from the eastern Bering Sea and Gulf of Alaska. If our estimates of theoretical yield rates for the northeastern Pacific are anywhere near correct, this means that the Soviets and Japanese are already accounting for about two-thirds of the total sustainable demersal fish production north of California. Some evidence suggests that the eastern Bering Sea may already be producing near or even beyond its sustainable capacity. If such is the case, the ever-expanding fleets of Japan and especially the U.S.S.R. can be expected to increase their fishing activities southward along the Pacific coast of North America. We have already witnessed an expansion of their activities in the Gulf of Alaska and can expect Soviet and perhaps Japanese trawl fleets to soon appear on our traditional trawling grounds off British Columbia, Washington, Oregon, and even California.

If we are to survive this increasing competition, it seems obvious that we must modernize our own fleets and fishing tactics. Through extensive exploratory fishing surveys we must provide our fishermen with detailed information on the distribution of demersal fishes off our coast, including those inhabiting presently unfished grounds and those which are not now marketed. We also must develop more efficient means of harvesting demersal fish through an expanded gear research program. We cannot afford to do otherwise lest we lose by default these potentially large protein resources which someday soon may be needed to help feed our expanding population.

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DISCUSSION

MR. MASON LAWRENCE (New York State Conservation Department, Albany, New York): What is the relation of this fishery to the present three-mile fishery jurisdiction and possible twelve-mile fishery jurisdiction?

MR. PRUTER: Of course at the present time all the fishing is occurring outside the three-mile limit. A twelve-mile limit is being adopted, apparently, by Canada this year, and one of the reasons that is given for this action is to prevent or to help prevent the Japanese and Soviets from fishing on some of the populations off British Columbia.

A twelve-mile limit would help to a degree in preserving some of our fisheries. A large part of how much help we would derive from it would depend upon where the line is drawn from, whether it is drawn from headland to headland or whether it would follow the contour of the coastline itself.

MR. WICK: You indicated a stock of 19 billion pounds, and then you gave figures of what is being harvested. Do you have any indication of what might be the mean annual yield?

MR. PRUTER: We have made some estimates of this, and they are crude also, but our best estimate is that the annual sustainable yield would be in the vicinity of three to four billion pounds per year.

MR. WICK: A couple of years ago a Senator from Massachusetts, whose name escapes me right now, gave a very fine speech, I thought, on the floor of the Senate, recounting all of these problems that commercial fisheries in the United States face, at least in the harvesting. Do you know if this has resulted in any action by the Congress?

DR. HARGIS: I can't answer that. How about you?

CHAIRMAN NORRIS: The speech you are referring to was by Senator Benjamin Smith, from Massachusetts, and as I recall, he had a seven-point program for commercial fisheries.

I can't say that any direct action has come from this, but there have been several things which he pointed out that have progressed part of the way through Congress. For instance, the subsidy bill, which would increase the subsidy payments on commercial fishing vessels from 33⅓ per cent to 55 per cent, was one of the things that he was talking about. That is the only one that comes to mind at the moment. It was a very broad program.

DR. HARGIS: Unless there are other questions or comments, this morning's session was concerned with Coastal and Marine Resources; "Resources for the Good Life" is the theme of the whole thing. It is an extremely difficult problem, dealing with estuarine and coastal resource management problems and techniques.

I don't know whether the gentleman who asked earlier—I guess his general question was "Why can't we get more positive answers from our scientists? Why must they always ask for more studies and more research?" That was a provocative question, just as was the one in the first part of the session.

I would like to comment here that we deal in the Federal Government and in State governments with management agencies, with people, with General Assemblies of the States and with the Congress of the United States. One of the things that we need in management of estuarine resources is more positive scientists. However, you always have to remember that scientists have to be careful, because you can drive them to the wall. They are not like lawyers, in which sometimes you can make statements that don't have to be necessarily founded.

The second thing is that we need more sympathetic and knowledgeable intermediaries in the management process; that is, the people who deal with the scientists and then go to the General Assembly or to the House of Representatives should know what they are doing. They should understand the problems scientists face and they should also understand the problems on the other side of the system, so that there is a matter of better education.

I must say it has been my impression over the years in attending these meetings that some of these people that are concerned with the intermediate problems are much less concerned with the technical problems involved than they are with the amusements in the places they go to.

In other words, there is an obligation incumbent upon not only the scientists being more positive but the intermediaries and their interpreters of science to be conscientious and to understand the problems of scientists. This, I guess, would lead to a better decision making process. The decision making processes we have now in management sources are pretty poor, very poor. Quite often there is very little attention paid to the biological, the scientific or physical facts. Quite often you can do a great deal of work, have a great deal of knowledge, and know that when it gets to the legislative body or the management agency that it is going to be filed in the nearest filing cabinet or sometimes in the wastebasket and not be consulted at all. This is a very disturbing thing.

So I guess the whole thing boils down to a more responsible approach on the part of scientists and on the part of the management-making officials; more attention to facts, less attention to political pressures which may or may not be founded on any fact at all. In short, we need a better resource management system.

I would say, however, in the end, to defend science, we do need more information. We could be much more positive if we had adequate information, and this is going to call for work. One of the problems has been, and we had a very striking illustration of this in Virginia—we have a problem in the James River, which is a prime oyster seed producing area. We have a discussion going as to whether a proposed channel-dredging will damage the oyster seed bed. This is the seed bed on which 70 per cent of all the oysters in the lower Chesapeake Bay depend and consequently it is a very important natural resource.

We have been discussing this problem back and forth since 1958, and the most recent action unfortunately was not based upon the scientific evidence but upon political pressures between the areas involved, one which thinks it is going to get a great deal of money out of it and one which thinks it is going to be damaged.

If the recommendations of the scientists, the technical people, that were made in 1958 had been followed, we would have the information now, instead of another delay for three more years to get the information. So that it is not entirely a one-sided thing.

We have made recommendations which have not been followed, positive recommendations which have not been followed, and we have consequently, or the management resource has consequently, suffered.

So I guess the best summary is that we need more information and we need better decision making processes, and we need more responsibility all the way around in managing costal resources.

Thank you.

TECHNICAL SESSION

Wednesday Morning—March 11

Chairman: Howard A. Miller
In Charge, Wildlife Management, Southern Region, U. S. Forest Service, Atlanta, Georgia

Discussion Leader: Joseph Townsend
Wildlife Management Specialist, Bureau of Land Management, Billings, Montana

FOREST AND RANGE RESOURCES

THE VALUE OF BIG GAME HUNTING IN A PRIVATE FOREST

Robert K. Davis[1]
Resources for the Future, Inc., Washington, D. C.

This paper reports on an attempt to quantify the benefits of big game hunting in a part of the Maine Woods. Benefits are defined by the sum of the maximum prices which the hunters would pay rather than be deprived of the privilege of hunting in the particular area studied. The study area, a tract of nearly 500,000 acres of private forest land located in the headwaters of the West Branch of the Penobscot River, affords a type of backwoods deer and bear hunting for which the Maine Woods has been well known for nearly a century. During the 1961 hunting season, the time of this study, the area was visited by 2800 hunters who spent about 15,000 hunter days on the area. About 40 per cent of the hunters were non-residents, coming mostly from southern New England and the mid-Atlantic states.

[1]David B. Brooks, John V. Krutilla, Burnell Held and Jack L. Knetsch made helpful comments on an earlier draft. The research work was supported by Resources for the Future, Inc., the National Wildlife Federation, the Great Northern Paper Company and the Federal Reserve Bank of Boston. The author is solely responsible for the results.

This area is also used extensively for fishing and camping, an estimated 7500 households visiting the area during the summer of 1961[1]. This use is made possible in part by a network of private all weather roads constructed to facilitate modern logging methods and opened to the public in response to the pressure of the automobile. The woods is virtually uninhabited and still has such an incomplete road network that it satisfies the requirements of most users as a wild, backwoods area.

The woods is not unchanging, however. On the next pulpwood cutting cycle the road system will be greatly intensified. Increasing use by campers will create demands for recreation development. The type and character of this development will have uncertain effects on recreational values. There is ample reason for social concern about the best management plan for this area, but forming any conclusion about what ought to be the pattern of future recreation development in this area requires a series of valuations. While we have objective market values for the forest products of these lands, we have no comparable measures of their values for recreation. Clearly we need some objective measures of the recreational value of these lands if we are to plan intelligently for the future. Such a measure of value is the goal of this study of the market demand, or willingness to pay, for hunting in this area of the Maine Woods.

SOME THEORETICAL CONSIDERATIONS

When properly functioning markets exist for the buying and selling of a good its price measures the social value of the last units traded. Market price reflects both consumer's willingness to pay for the good and producer's cost of furnishing the good. As I have argued elsewhere, the unique, personal and sometimes mystic values attributed to recreation are irrelevant to the question of the usefulness of economics as a tool for recreation planning. (Davis, 1963b). In order for consumer's willingness to pay to have the meaning ascribed to it, it is only necessary that consumers are acting rationally on good information and that all benefits from consumption are specific to the consumers.

There are especially good reasons for believing that big game hunting as a commodity satisfies the requirements of economic analysis. After all, big game hunting involves considerable expenditure of time and money and often employs consumer equipment worth several hundred dollars. In view of this, it is inconsistent to argue that the

[1]Users were registered by the Great Northern Paper Company at a traffic station on the only highway access point to the study area. A household could be one member, as with hunters, or an entire family as typical of summer visitors.

consumers are incapable of making rational choices toward the things of value which they obtain while hunting. If a hunter's health and well-being are aided by hunting, he may be presumed to know the full value of these effects. Likewise, it is deceptive to argue that big game hunting confers benefits on society at large. The benefits are specific and not general. It follows that big game hunters' willingness to pay for the use of their hunting grounds is a valid measure of the current social benefits of big game hunting.

Although a few cases are found where access to hunting or fishing is marketed with some semblance of organized buying and selling, it is doubtful if there is enough market development to support unambiguously the suggested use of current "prices" for valuing wildlife resources. (Bolle and Taber, 1962, Task Force, 1962) Upon closer examination such markets might be found to behave in quite erroneous and misleading ways.

Where there is no organized market for a good we must resort to simulation techniques if we are to place a monetary value on the benefits of the good. Various suggestions have been discussed for simulating recreation demand curves from inferred consumer valuations. (Knetsch, 1963, Crutchfield, 1962, Hufschmidt *et al.*, 1961, Clawson 1959.) For this study a user experiment was employed to directly obtain consumer valuations.

THE EXPERIMENTAL METHOD

The willingness to pay of a sample of users was determined in interviews on the site. The interviews included, among other things, a bidding game in which respondents could react to increased costs of visiting the area. Bids were systematically raised (or lowered) until the user switched his reaction from inclusion to exclusion (or vice versa). The interviews were designed to minimize the chances for a respondent to consciously bias the outcome. Non responses due to the inability of respondents to play the game occurred in 12 out of 121 total interviews. In general interviewees were relaxed and cooperative.[2]

The sampling procedure amounted to cluster sampling since the procedure was to locate areas of use such as campgrounds, and to se-

[2]Several features of the interview technique are believed essential to its success. It would seem essential that the subjects of the interview be users of the recreation area involved. The interviewer was explicitly disassociated from any private or public organization that might influence policies on the area. The beginning of the interview was used to establish rapport with the respondent and also to develop economic background information on his participation in outdoor recreation, reasons for selecting this area, expenditures and certain other data. The bidding questions were mixed with a series of propositions for which the respondent was requested to indicate a positive, negative or neutral reaction. His reactions to increased expenses connected with the visit were determined to a starting bid which was successively doubled or halved until an opposite reaction from the initial one was obtained. Personal data questions regarding income, education and the like were confined to the end of the interview.

lect a systematic sample from the cluster of users. The sample from which these results are derived is pooled from interviews of both hunters and summer users on the study area, summer users from nearby Baxter State Park, and a few hunters from another private tract.

The only unique problems in interviewing the hunters came from the necessity of locating them in their camps at night or on the roads at lunch time or other breaks in the hunting. A wide cross section was sampled by taking advantage of all such opportunities. Some hunters were reached by group interviews which were successful but posed some weighting problems in subsequent analysis.

Demand curves showing how quantity demanded increases as price is lowered are derived from this data simply by arraying the responses of willingness to pay per household unit and cumulating downward. That is, the number of buyers who would pay as much or more than a given price is calculated for each price. The resulting distribution function shows the number of households who will be in the market at any price. It is worth noting that the demand curve attributed to an individual by this process shows that he uses the area by a constant amount below a certain price (his willingness to pay) and he uses the area not at all above this price. There is a good bit of realism in this treatment of the alternatives facing a non-resident hunter. The economics of this question are discussed more fully elsewhere. (Davis, 1963a)

THE DETERMINANTS OF WILLINGNESS TO PAY

The willingness to pay responses were subjected to multiple regression analysis in order to test the rational structure of the responses. The hunter interview subsample was tested separately but no significantly different regression equation was found to explain hunter willingness to pay.[3] Therefore the interviews were pooled in order to gain statistical reliability.

The best explanatory equation (Equation 1, Table 1) explains willingness to pay per household visit as a function of one's income, length of stay in days and acquaintance with the area in years. The logic of these explanatory relations is appealing. Income reflects one's ability to pay for a commodity. It is also generally true that demand for outdoor recreation increases with income. Thus on both counts we would expect income to be a determinant of willingness to pay.

The length of time one stays in the area appears to measure the quantity of good consumed but also reflects a quality dimension,

[3]The statistical test employed the F ratio to test the equality of the corresponding multiple regression coefficients in the sub-group regressions. (Foote, 1958, p. 180.)

TABLE 1. REGRESSION EQUATIONS[a]

Equation	R^{2b}
1. $W = -48.57 + \underset{(1.52)}{2.85Y} + \underset{(0.58)}{2.88E} + \underset{(1.03)}{4.76L}$	.5925
2. $W = .74L^{.76}E^{.30}Y^{.60}$ (.13) (.07) (.17)	.3591[c]

Standard errors of equations: (1) 39.7957; (2) 2.2007.
Standard errors of coefficients are shown in parentheses.
[a] W = household willingness to pay for a visit.
E = years of acquaintance with the area visited.
Y = income of the household in 1000's of dollars.
L = length of visit in days.
[b] F ratios of both equations are highly significant.
[c] Obtained from arithmetic values of residual and original variances.
R^2 of the logarithmic transformation is .4309.

suggesting that longer stays probably reflect a greater degree of appreciation for the area.

Years of experience in using the hunting area seems to contain a complex set of explanatory relations. In general the more years of experience a hunter has in using a hunting ground the greater satisfaction he obtains from it.

Economical consistency and rationality of the responses appear to be agreeably high. During the bidding game respondents' comments indicated they were turning over in their minds the alternatives available in much the same way a thrifty shopper considers the price and desirability of different cuts or kinds of meat. Moreover, certain income related responses to other preference questions suggest an economic consistency in the responses. Both our success in finding logically tenable explanatory variables and this internal consistency suggest that a considerable reliability can be attached to the users' estimates of their willingness to pay.

THE SIMULATED DEMAND FOR HUNTING

The results of the interviews do not serve as direct estimates of hunter's willingness to pay because the income, length of stay and years experience of the interviewed sample do not represent the characteristics of the population of hunters. Therefore the hunter population was sampled for reliable information as to their characteristics.[4] The entire hunter population was then distributed according to the sample distribution of income, length of stay and years of acquaintance with the area. The willingness to pay of each class was computed from a logarithmic estimating equation. (Equation 2, Table 1.) The linear explanatory equation could not be used for this purpose because, while it performs well for the range of user types sampled

[4] This information was collected by a questionnaire administered to a systematic sample of hunters stopping at the traffic checking station. Questionnaires were administered on Saturday, Sundays and Mondays. Most hunters arrived on the sampling days and spent a week hunting the area. Usable questionnaires were obtained from 390 hunters, giving a satisfactory confidence interval.

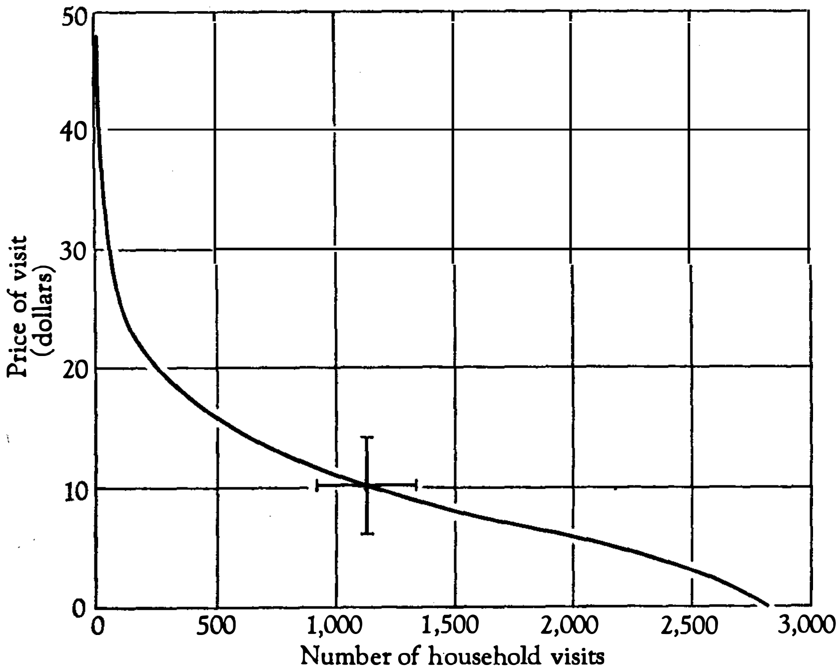

Fig. 1. Simulated demand for hunting in number of household visits for stated prices. The vertical line through the mean represents the 95 per cent confidence interval of the price estimate while the horizontal line represents the 95 per cent confidence interval of the cumulative distribution.

in the interview, it does not extrapolate satisfactorily to the lower income, short stay users not so well represented in the interview sample.

The demand curve in Figure 1 was derived from the simulated distribution of willingness to pay by cumulating the distribution at successively lower prices.[5] The essential notion behind this curve is that households will be excluded as price increases. The confidence intervals shown on the curve represent the errors of the estimating equation and of the cumulative distribution of the population. The curve may be visualized as anchored to the quantity axis but subject to errors of shape and interception with the price axis. The errors do not appear serious.

The shape of the curve reveals a fairly high sensitivity to price in the range from $5 to $20. This would be taken into account if policy for charging everyone a uniform price were considered for this area. Although price cannot be set without some knowledge of the costs of providing various amounts of hunting, it is instructive to examine the

TABLE 2. SIMULATED DEMAND AND WILLINGNESS TO PAY OF HUNTERS IN UNITS OF HOUSEHOLD VISITS

Class lower limit[1]	Frequency[2]	Cum. Frequency[3]	Total Revenue[4]	Willingness to pay
$			$	$
48	7.16	7.16	343.68	350.84
38	7.16	14.32	544.16	630.08
36	14.32	28.64	1031.04	1159.92
34	14.32	42.98	1460.64	1661.12
32	7.16	50.12	1603.84	1897.40
30	7.16	57.28	1718.40	2119.36
28	14.32	71.60	2004.80	2534.64
26	28.65	100.25	2606.50	3308.19
24	21.49	121.74	2921.76	3845.44
22	21.49	143.23	3151.06	4339.71
20	93.15	236.38	4727.60	6295.86
18	150.46	386.84	6963.12	9154.60
16	179.13	565.97	9055.52	12199.81
14	143.30	709.27	9929.78	14349.31
12	279.43	988.70	11864.40	17981.90
10	265.10	1253.80	12538.00	20898.00
8	293.76	1547.56	12380.40	23541.84
6	372.58	1920.14	11520.84	26149.90
4	272.27	2192.41	8769.64	27511.25
2	472.89	2665.30	5330.60	28929.92
0	150.45	2815.75[6]	000	29080.37
		Average per household		10.32

Notes.
[1] Class lower limit is stated as price of a household visit.
[2] Frequency in units of household visits.
[3] Frequency cumulated on a greater-than-lower-limit basis.
[4] Product of columns 1 and 3, price × quantity.
[5] Represents the total area of the curve above the stated price. Calculated by summing the products of class frequency × class midpoint.
[6] Total household days represented is 14,817.

total revenue or price times quantity column of Table 2. There we note that all prices in the range from $6 to $12 do about equally well in maximizing total revenue. Thus if it involved no substantial differences in producer costs, we might prefer charging $6 rather than $12 in order to minimize the number of excluded hunters or hunting trips.

The appropriate measure of the gross annual social value of this hunting area is current total willingness to pay for the area. This is calculated by summing the willingness to pay of everyone in the demand curve above zero price. The estimate for this sum is $29,080 or an average of $10.32 per household. (Table 2.) (This is also an average willingness to pay per household day of $1.96.) The question is how significant this benefit sum is as a land rent. The market value of this land is presently based on its productivity as forest land. The study area has a value of $4.8 million (Maine Board of Taxation, 1960). At seven per cent annual rent this land should be returning about $336,000 to its owners. Our estimates show that it has an ad-

[5]Although it would be more conventional to express consumption and price in user days the responses conclusively show that the household is the significant consuming unit whether represented by one hunter or an entire family. Implicitly the number of visits can be converted to household days from the information on length of stay, but this does not affect either total revenue or total benefits.

ditional social productivity of $29,000 as a hunting area or public value equal to 8.6 per cent of its private value.

The analysis has thus far neglected the private costs of providing public hunting in this forest. Increased fire risk and the sacrifice of timber production appear to be negligible costs. There may be sizable disutilities imposed on the empolyees of the landowners by the intrusion of hunters into the woods but this cost remains unquantified. The costs of harvesting the wood crop are probably increased somewhat during hunting season (Hall, 1963). At the same time our estimate of benefits neglects certain hunters who enter the area by airplane and the net rents landowners collect from a number of hunting camp leases. When these are considered together with the conservative bias of the estimating equation we may call these estimates reasonable approximations of the net annual productivity of big game hunting on this area.[6]

CONCLUSION

We have found a substantial and measurable willingness to pay on the part of big game hunters using an area of the Maine Woods. The interview method used in this study must be considered experimental at present, but its success in eliciting responses which possess internal consistency and an apparently rational structure certainly demonstrates that it deserves further attention. In particular the stability of the responses and their variance under different interviewing procedures merit study.

Potentially, simulated market information on benefits can be used to improve decision making in recreational planning. Such information enables resource administrators to strive for optimum social welfare in their decisions with a precision that contrasts sharply with the arbitrariness and capriciousness that exist when market valuations are lacking.

If we accept the estimated willingness to pay of these hunters as measuring the marginal social value of hunting on this area then what does this measure of value tell us?

In the first place it indicates that hunting is a significant social product of this land in relation to its private productivity (and of course total recreational use of this tract represents an even greater proportion of its total productivity). Moreover, under present demand conditions some combination of hunting, other recreational uses

[6]Costs to the state wildlife agency of administering the hunting season and carrying out wildlife management projects in this area are assumed to be equal to the hunting license revenue derived from the area (Forty per cent of the hunters pay the $25 non-resident fee.) If in fact license revenues from this area subsidize activities in other areas of the state, then the area produces another social benefit. In addition, each hunter brings some Federal Aid money to the state.

and forest production appears more productive than any exclusive use of the tract. Finding the best combination of uses for this land can proceed from our knowledge of the willingness to pay of hunters and other users, and from a great deal more information on costs.

More than information is lacking. There are institutional deficiencies in this area of the Maine Woods where no private agency has an economic incentive to develop and use such information and no public agency has a legal responsibility to do so. As matters stand now the correct weight of the social values cannot be registered on the owners' management decisions. The owners will take the full private and public consequences of their decisions into account only if led to do so by programs of government regulation and compensation or through marketing arrangements which permit them to capture some of the social values created through hunting on their tracts. We need not dwell on the obvious fact that road building, forest management and recreation developments in the Maine Woods will affect the future values of hunting. There is a chance that the outcome under present arrangements could be far from the best attainable. The question is, what steps might increase the chances for socially desirable land management decisions to be taken here?

It has been noted that most of the wildlife management policies directed toward private lands have taken the form of direct public action, while, at the same time, the working out of private marketing arrangements has been considered nearly impossible. (Berryman, 1961). On the contrary, I think that many of our wildlife production and harvesting problems can be solved through more reliance on market processes and the production incentives that accompany opportunities for private gain. I would agree, however, that the market cannot be turned loose with the expectation of socially satisfactory results.

Let me suggest that greater reliance on private production and marketing arrangements guided by an appropriate set of rules presents three problem areas in need of research and policymaking attention: (1) Producers must have vastly improved information on the costs and returns of wildlife management practices if they are to act intelligently; (2) Individual producers' actions will need to be coordinated for the reason that the range requirements of both the hunter and the hunted frequently transcend individual property boundaries. This is a problem involving both the distribution of production efforts and their returns; (3) Orderly marketing arrangements are a requirement if an efficient distribution of hunters is to be accomplished. Without dwelling on the meaning of efficiency here, let me point out that this last requirement means there is a need for both effeetive bargaining arrangements and adequate transmission of market information so that hunters can register their preferences and producers their costs in the price-making process and so that hunters can follow accurately the lead of their preferences in the choice-making process.

To be sure, I have ended with a large order, but there are some significant present and future values at stake here and the payoffs from the approach of research and social invention which I have sketched appear to be very large. The problems of recreation planning on large tracts of private forest would appear to be a good place to make a start.

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DISCUSSION

DISCUSSION LEADER TOWNSEND: Thank you, Mr. Davis.

We are constantly asked by other users of the land as to the value of wildlife and recreation on the land. We know these values cannot be measured in dollars but occasionally we are forced to measure them in dollars.

In this day of multiple-use and the multiple-use concept, we have a very great need for some measure, perhaps not entirely in dollars, but in some ways we will have to measure the various demands and the intensity of these demands for uses of the land.

I believe that work such as Mr. Davis has done here is certainly going to be a contribution to our techniques in doing these jobs.

MR. H. R. CHILDS (University of Idaho): I think this was a very stimulating paper. I wonder if you would care to comment on the question—does the market give adequate valuation to resource conservation or is it strictly exploitive?

MR. DAVIS: Well, that is an important question.

I think much of the conservation movement has been a reaction to the shortsightedness of the market. However, we have come a long way, I think, in corraling the market and adjusting its weaknesses or adjusting for its weaknesses.

In this particular type of analysis, there is no reason why conservation values cannot be recognized. I would be the last to recommend a pure 19th Century private capitalist approach to problems of this sort because there is a need for a mixed public-private approach to the problem of wildlife production on private land. I think future values can be adequately accounted for in this type of an approach.

MR. CHILDS: What are the influences of area closure on recreational fees and, if these influences are contrary to maximizing landowner profit, how might they be overcome?

MR. DAVIS: In deriving the demand curve, the assumption was that the price was varying on this area and was in fact zero on other areas. If there had been prices imposed on the other areas which the hunters might have used, they would have affected the shape of this demand curve. When it comes down to maximizing the net values of hunting on a particular area in a situation where there may be a range of prices on alternative hunting opportunities, this becomes a question of market strategy. Sometimes the conditions are sufficient that this type of problem can be solved and at other times the solution is indeterminate. Nevertheless, it is an area that I think can be handled.

MR. CHILDS: One more question. I think you present a very exciting idea that big game does not confer general benefits on society but that these benefits are strictly for the individual. That is, they are specific. I wonder if you will comment more on this concept?

MR. DAVIS: There is a concept here that is important.

If consumer valuations and if hunter willingness to pay means anything—that is, if a man is made easier to live with, more productive on the job, and, further, he is not aware of these values and does not take them into consideration, then there is a deficiency in his willingness to pay. However, if he is aware of these benefits, then, of course, his valuations are the social values.

DISCUSSION LEADER TOWNSEND: Are there further questions?

MR. SCHEMNITZ (Maine): Did you notice, in the analysis of your data, any difference in willingness for residents to pay versus non-residents?

MR. DAVIS: The difference can be explained partly by the variables in the equation. The out-of-state, non-resident hunters, have a higher income. Generally, they are staying in the area longer and may or may not have more years of experience in using the area. This, non-residents have the higher willingness to pay.

These areas do have a fairly stable population of non-resident hunters. They have been coming back for years. This alone explains the differences in the resident and non-resident willingness to pay.

There are some other differences which may be too detailed to go into at this point.

DEER, ELK, AND CATTLE RANGE RELATIONS ON SUMMER RANGE IN UTAH

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Mule deer (*Odocoileus hemionus*) are found on all cattle summer ranges in Utah and many adjacent states. A third grazing animal, elk (*Cervus canadensis*), shares much of this same range. An important problem on these ranges is integrating deer, elk, and cattle use to perpetuate the forage resources and correlate grazing use with watershed and other values.

The objecive of the study reported here was to evaluate the habitat factors, both biological and physical, in an effort to determine which make habitat favorable or unfavorable for deer, elk, and cattle. Thorough regression analyses have not yet been completed. Significance of interactions and combining similar data from one or two other study areas for complete analyses are yet to be completed. Hence, results reported here are somewhat tentative, and time will permit discussion of only the more important factors.

Previous reports have dealt with deer and cattle range relations (Julander and Robinette, 1950; Kimball and Watkins, 1951; and Julander, 1955). Cliff (1939) reported on range relations between elk and mule deer on overstocked winter range in Oregon and pointed out that elk have the advantage over mule deer under severe competition. We know of no former study on the relation of deer, elk, and cattle on summer range or of the site factors associated with range use by these animals.

STUDY AREAS

Results reported herein are from Willow Creek range on the Fishlake National Forest in Utah.

The Willow Creek study area occupies the entire upper part of the drainage extending from the lower edge of the aspen type at about 7,800 feet up to the ledged rim near the top of the Wasatch Plateau at an elevation of about 10,500 feet. The area includes roughly 8,000 acres of broad canyon drainages with rolling swales, small basins and ridges, and is bounded by steep slopes on either side and at the head. This topography provides slope exposures facing all cardinal points of the compass. Slopes vary in steepness from 0 to approximately 75 percent. Water is relatively plentiful and well distributed.

Aspen is the main cover type throughout the area with more lim-

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ited areas of conifer, mixed aspen-conifer, mixed shrub, grass-forb, and a small area of Gambel oak at the lower elevation. The range is considered to be in fair condition with serious over-use only on localized areas readily accessible to cattle. Based on fecal group counts, cattle make up roughly 57, deer 26, and elk 17 percent of the total animal days' use on the area up to about September 15. Cattle start grazing the lower part of the study area shortly after June 1 and are all removed October 1. Deer and elk graze the area from about the middle of April until late in the fall.

METHODS

Sixty-five study sites, each 10 acres in size, were located by a random grid placement on an aerial mosaic. Each study site was sampled by random line-plot transects to estimate animal days' use and pounds of herbage per acre. Fecal group counts of deer, elk, and cattle, were made on 335.08-square-foot circular plots (10.32 feet radius). Counts were first made in late spring (last of June) and repeated on the same plots in summer (last or July) and in the fall (middle of September). During each count, fecal groups were sprayed with paint to avoid recounting later. The counts then represent animal days' use for spring, summer, and fall, and the total of these counts represents total grazing use for the study period. Allowing 13 fecal droppings per animal day, the average plot count x 10 converts to animal days' use per acre.

Herbage yields were estimated in grams on 9.6-square-foot circular plots. The average plot estimate x 10 converts to pounds per acre. Other factors (a total of 25) quantifiable and non-quantifiable, were measured or estimated for the 10-acre study site as a whole. Exposure was indexed as a coded value obtained by determining the sine of the angle of the exposure from 135° azimuth and adding 1.000 as described by Van Dyne and Kittams, 1961. Some factors, particularly density of shrub and tree crown cover, topographic position (location in respect to topography and elevation), slope length, and distances to edge of type and to water, could best be determined from aerial photographs and were interpreted by Karl E. Moessner of the Intermountain Forest and Range Experiment Station.

Analyses of variance were run of animal days' use of deer, elk, and cattle in relation to the two non-quantifiable site factors: (1) topographic position, and (2) vegetation type. Multiple regression analyses were used to determine the relative influence of all measured quantifiable site factors (23) on the distribution of deer, elk, and cattle on the range as estimated in animal days' use by fecal counts. A partial screen was run, and all factors with partial regression coefficients showing t values less than 0.6 were eliminated as having little effect on animal distribution. Regression analyses, with all possible combinations were run on the 11 to 13 selected independent variables and the 4 dependent values (spring, summer, fall, and total animal days' use) for each of the three kinds of animals.

Quadratic regressions were run on several independent variables including length of slope, percent slope, distance to edge, shrub density, elevation, and production of forbs and browse. These did not show the relations as well as the linear regressions, so were not run in the final analyses. The following interactions of independent variables: percent slope and rock cover, percent slope to water and distance to water, distance to water and exposure, and others involving exposure, may be important, but they cannot be evaluated with the present analyses. They will be studied thoroughly when data from three study areas in Utah are combined for analyses.

In tests for significance of differences in biological data collected over large areas, such as that presented here, we cannot say with certainty that factors which failed to show significance at the 5 percent level may not be important. For this reason, in addition to the usual 1 and 5 percent levels, we have chosen to also use 10 and 20 percent levels of significance. Significance was determined by the t test of the partial regression coefficeints and shows the relation with each individual X variable has with the Y variable when all other X variables are held constant.

Because of lack of space, only significant data (1, 5, 10, 20 percent levels) for summer and total days' use are presented. Spring and fall data are discussed when data are significant at one of the above levels.

RESULTS—ANALYSES OF VARIANCE

VEGETATION TYPE

Six distinct vegetation types are present on the Willow Creek area: (1) aspen, (2) aspen-conifer, (3) open conifer, (4) mixed shrub, (5) grass-forb, and (6) Gambel oak. All types contain good mixtures of grasses, forbs, and browse except the grass-forb type which produces relatively small amounts of browse. The two most extensive types, aspen and mixed shrub, are the heaviest producers of total herbage within reach of animals. The grass-forb type is consistently high in grass production. Other types have grass locally abundant, but generally less than in the grass-forb type.

Mean deer and cattle days' use of the various vegetation types indicate their relative preference for the types (Table 1). Elk days' use, although not statistically different between types, may be assumed to indicate to some degree the relative preferences of elk, and are pre-

TABLE 1.—VEGETATION TYPES IN ORDER OF PREFERENCE FOR DEER, ELK, AND CATTLE. TOTAL GRAZING USE AS INDICATED BY FECAL COUNTS

	Deer‡		Elk NS		Cattle**	
Preference	Veg. Type	Days' Use/Acre	Veg. Type	Days' Use/Acre	Veg. Type	Days' Use/Acre
First	Mixed Shrub	6.4	Mixed shrub	3.9	Grass-forb	16.2
Second	Oak	5.3	Aspen	2.8	Mixed shrub	10.3
Third	Aspen	4.2	Oak	1.8	Aspen	7.7
Fourth	Conifer-shrub	3.7	Grass-forb	1.8	Aspen-conifer	4.9
Fifth	Aspen-conifer	2.1	Aspen-conifer	1.7	Oak	3.0
Last	Grass-forb	0.7	Conifer-shrub	1.7	Conifer-shrub	1.3

** Differences in animal days' use significant at the 1 percent level.
‡ Differences in animal days' use significant at the 10 percent level.
NS Differences in animal days' use non-significant at 20 percent level.

sented for comparison with deer and cattle. Seasonal use, although not shown in the table, will be discussed.

Deer preferred the mixed shrub, oak, and aspen types in the order listed. Differences in total use by deer were significant at only the 20 percent level (Table 1), but were significant at the 5 percent level for spring use. Apparently deer were selective in their use of types in the spring, but by fall had extended their grazing to other types. This agrees with field observations.

Elk preferred the mixed shrub, aspen, and oak types in the order listed. The differences were non-significant at the 20 per cent level. Apparently elk are influenced less by vegetation types than are deer or cattle.

Cattle preferred the grass-forb, mixed shrub, and aspen types in the order listed. Differences in cow days' total use of the various types were significant at the 1 percent level (Table 1). Differences were also significant at the 1 percent level for fall use and at the 5 percent level for summer use.

The aspen and mixed shrub were among the three most preferred types for deer, elk, and cattle, as indicated by grazing use (Table 1). Deer and elk preferences were very similar. Mixed shrub type was first preference, with aspen and oak types as either second or third choice. The grass-forb type, which was first choice by cattle, was the least preferred by deer and one of the least for elk.

Cattle preference for vegetation types remained constant, but deer and elk preferences changed with the season. This perhaps accounted for the smaller differences, among the various types, in total use by deer and elk. Deer preferred the oak type in early spring but later grazed more in the conifer-shrub, mixed shrub and aspen types. Elk showed a preference for the grass-forb type in summer, but in spring and fall it was one of the least preferred types. The shrub type was one of the three most preferred types by elk in all seasons. In the fall, the conifer-shrub type, containing much shrub herbage, became important to elk.

TOPOGRAPHIC POSITION

Each study site was classed according to its position in relation to topographic position and elevation in one of the six following categories: (1) upper slopes, (2) middle slopes, (3) lower slopes, (4) major ridgetops, (5) upper finger ridges, (6) lower finger ridges.

Deer preferred the upper slopes, major ridgetops, and middle slopes, with the lower slopes and lower finger ridges the least desirable. Differences in total deer use of range at the various topographic positions were significant at the 1 percent level (Table 2). Also, differences in deer use of topographic position during the fall were significant at the 5 percent level, and those for summer use were significant at the 1 percent level.

Elk preferences are essentially the same as for deer, with upper slopes, middle slopes and major ridgetops being first choice in the order listed, and lower slopes and lower finger ridges the least desirable (Table 2). Elk were least influenced by topography. Differences in their use of the various topographic positions were non-significant at the 20 percent level. However, the mean animal days' use may give some indication of elk preferences.

In contrast to deer and elk, cattle preferred the lower finger ridges and lower slopes, and major ridgetops and upper finger ridges were the least attractive (Table 2). These differences were significant at the 1 percent level for fall and for total use.

Animal days' use of the preferred positions was several times greater than on the least preferred positions for each of the three kinds of animals.

Preferences of cattle for topographic position remained about the

TABLE 2.—TOPOGRAPHIC POSITION IN ORDER OF PREFERENCE BY DEER, ELK, AND CATTLE, TOTAL GRAZING USE AS INDICATED BY FECAL COUNTS

	Deer**		Elk NS		Cattle**	
Preference	Topographic position	Days' Use/Acre	Topographic position	Days' Use/Acre	Topographic position	Days' Use/Acre
First	Upper slopes	8.0	Upper slopes	4.1	Lower finger ridges	13.1
Second	Ridgetops	3.6	Middle slopes	2.5	Lower slopes	12.7
Third	Middle slopes	3.2	Ridgetops	2.3	Middle slopes	11.9
Fourth	Upper finger ridges	2.3	Upper finger ridges	2.2	Upper slopes	6.4
Fifth	Lower slopes	1.6	Lower slopes	1.8	Upper finger ridges	5.1
Last	Lower finger ridges	1.3	Lower finger ridges	1.2	Major ridgetops	3.5

** Differences in animal days' use significant at the 1 percent level.
NS Differences in animal days' use non-significant at the 20 percent level.

TABLE 3.—INDEX OF ANIMAL DAYS' USE PER ACRE AND PERCENTAGE OF TOTAL USE FOR THE THREE SEASONS FOR DEER, ELK, AND CATTLE, IN RELATION TO STEEPNESS OF SLOPE ON WILLOW CREEK RANGE

		Index of Animal Days' Use/Acre			% of Total		
% Slope	No. Plots	Deer[1]	Elk NS	Cattle[1]	Deer	Elk	Cattle
0–10	10	2.9	3.4	17.1	13	27	43
11–20	20	4.3	2.8	7.7	19	22	20
21–30	18	3.5	3.0	8.0	16	24	20
31–40	10	5.2	2.1	4.8	23	16	12
41+	7	6.5	1.4	1.9	29	11	5
Totals	65	22.4	12.7	39.5	100	100	100

[1] Differences in animal days' use significant at the 5 percent level.
NS Differences in animal days' use non-significant at the 20 percent level.

same throughout the study period. Preferences of elk, however, shifted some with season. Upper slopes remained important, but in the fall, middle slopes and upper finger ridges became less important, and preference for major ridgetops and lower slopes increased. Reasons for this shift are not known.

RESULTS—MULTIPLE REGRESSION ANALYSES

STEEPNESS OF SLOPE

The greatest deer use was on slopes of 30 to 40 percent or greater (Table 3). Elk use was about the same on various slopes up to 30 percent and decreased somewhat on steeper slopes. Cattle use was greatest on 0 to 10 percent slopes and decreased sharply on slopes over 30 percent. These estimates show that slopes over 30 percent received 52 percent of the total deer use, 27 percent of the total elk use, and only 17 percent of the total cattle use on the Willow Creek summer range.

Steepness of slope was positively related with intensity of deer use in summer (significant at the 20 percent level), and this relation became significant at the 5 percent level in fall and for total days' use (Table 4). In other words, deer made more use of range on the steeper slopes than the gentler slopes, particularly in summer and fall. Conversely, steepness of slope was negatively related with total cow days' use with significant differences at the 5 percent level. Cattle preferred the level and more gentle slopes. Slope steepness itself is believed to be directly responsible for the negative relation with cattle use. With deer, the better forage found on steep slopes, ungrazed by cattle, and possibly the disturbing effect of human activity in canyon bottoms, may be factors in determining the more intensive deer use on steep slopes.

As with the previous factors discussed, the effect of steepness of

TABLE 4.—PARTIAL REGRESSION COEFFICIENTS (B VALUES) FOR SITE FACTORS AS RELATED TO ANIMAL DAYS' USE BY DEER, ELK, AND CATTLE FOR SUMMER AND FOR TOTAL DAYS' USE FOR SPRING, SUMMER, AND FALL SEASONS COMBINED

	Deer days' use per acre		Elk days' use per acre		Cattle days' use per acre	
Site Factors	Summer	Total	Summer	Total	Summer	Total
Percent slope	+0.2804/	+3.7545*	+0.2487NS	−0.0150NS	−0.5749NS	−3.7278*
Distance to edge of type	−3.6940*	−4.4312*	−0.1587NS	−2.5089*	+0.6301NS	−1.4563/
Shrub density (% cover)	+9.5731//	+29.0673*	+0.4935NS	−0.038NS	−36.5785NS	−10.5793/
Grass utilization (%)	+0.0454*	+0.1007*	NS	NS	+1.7276NS	+2.8270*
Shrub utilization (%)	+0.4652*	+0.4150*	NS	NS	+0.9796NS	+1.1936*
Distance to water	+0.0646/	+0.8302*	+0.6136NS	−0.0353NS	+1.2813NS	−4.9435NS
Exposure	+0.0027//	−0.0104*	−0.0034//	+0.0027//	−0.0081NS	+0.1361//
R Square		0.69		0.49		0.77

* Significant at the 5 percent level.
// Significant at the 10 percent level.
/ Significant at the 20 percent level.
NS Non-significant at the 20 percent level.

slope on elk use is less than for the other animals. Differences due to slope were not significant for any season.

EDGE EFFECT

Distance from edge of type was negatively related with intensity of deer, elk, and cattle use, indicating the value of type edges to all three kinds of animals. The edge effect was more pronounced for deer, being negatively significant at the 5 percent level both summer and for total use (Table 4). For elk, distance from edge was significant at the 5 percent level for total days' use only. For cattle, distance from type edge was associated with total cattle use, but was significant only at the 20 percent level.

SHRUB DENSITY

Shrub density appeared to influence deer and possibly cattle distribution at Willow Creek. The relation was positive and significant at the 10 percent level in summer and the 5 percent level for total use for deer (Table 4). For cattle, the relation was negative and significant only at the 20 percent level for total use. Apparently brush range, which was little used by cattle because of its density, provided valuable habitat for deer. Most of these dense stands of brush are composed of chokechery (*Prunus virginiana melanocarpa*) with mixtures of serviceberry (*Amelanchier alnifolia*) and snowberry (*Symphoricarpos oreophilus*). Chokecherry and serviceberry are both considered good deer forage plants on summer ranges. As with many other site factors, elk use apparently was little affected by density of shrubs.

FORAGE UTILIZATION

Grass utilization was positively related (significant at the 5 percent level) with intensity of cattle use in fall and for total use as would be expected (Table 4). Differences were non-significant at the 20 percent level for summer. Utilization of grass was positively related with deer use (significant at the 5 percent level) for both summer and total use. This was unexpected since deer usually eat but little grass except in early spring. There may be interactions with other factors which have not been detected. No relation was found between grass utilization and elk use.

Shrub utilization was positively related with deer use and was significant at the 5 percent level for both summer and total use. For elk the relation was non-significant at the 20 percent level. For cattle the relation was positive but was significant (5 percent level) only for total use.

DISTANCE TO WATER

Distance to water was positively related with deer use. Differences were significant at the 20 percent level in summer and at the 5 percent level for total use. Better forage away from water than close by may be responsible for this positive relation. Elk and cattle use showed only non-significant differences (20 percent level) with distance from water. Some were negative and some were positive with no clearcut effects shown. At Willow Creek, water is relatively well distributed and may not affect cattle use here as it apparently does on many ranges.

EXPOSURE

Exposure was positively related with deer use in summer and negatively related for total use. The differences were significant at the 20 and 5 percent levels. The coding method used assigns the lowest numerical values to slopes of northeast exposures and highest values to those facing southwest. Hence, deer seem to favor southwesterly slopes in summer and northeasterly slopes later in the season. For elk the relation was reversed, being negative for summer and positive for fall. Differences were significant at the 10 percent level for elk (summer and total use). For cattle they were significant at the 10 percent level for total use but non-significant for summer use.

DISCUSSION

Statistical models used in this study leave considerable variance for which we cannot account, particularly for elk. R square values for total use used as an index to the variability accounted for are: 0.69

for deer, 0.49 for elk, and 0.77 for cattle (Table 4). We then have 31 percent, 51 percent and 23 percent variation respectively for deer, elk, and cattle for which we cannot account. This is not unusual with biological data. Many factors such as natural habits, weather, and insects, which might have seasonal effects on animal distribution, were not measured.

This study points out some important interrelations of deer, elk, and cattle grazing, and gives some indications of what makes a range desirable or undesirable for the different animals.

Deer and elk grazing habits on summer range are closely related as shown by their preference for the same vegetation types and same topographic locations most of the season. However, deer make more use of the steeper slopes (above 30%) and dense browse areas than do elk or cattle.

Elk apparently are less demanding of a habitat (fewer factors are significantly related with their use of a range) than either deer or cattle, and thus, in many ways, their habitat overlaps with both deer and cattle. For example, elk make relatively more use of moderately steep slopes and dense brush areas than do cattle, and they make relatively more use of the gentler slopes and of grass-forb type in summer than deer.

Cattle are more restricted in their use of the range than either deer or elk. Steepness of slope alone excludes use of certain large areas by cattle. A combination of steepness of slope and distance to water may be even more restrictive on many ranges. These factors have very little effect on deer use and only moderate effect on elk use.

SUMMARY

Mixed shrub and aspen types were among the three most preferred types for deer, elk, and cattle. These are the two highest forage producing types on Willow Creek range. Mixed shrub type was first choice for both deer and elk and second choice for cattle. First choice for cattle was the grass-forb type which was the type least used by deer and one of the types least used by elk.

Deer and elk preferred the upper slopes, major ridgetops, and middle slopes, while cattle preferred the lower finger ridges, lower slopes, and middle slopes.

The heaviest deer use was on steep slopes of 30 percent or more. Elk use was about equal on slopes from 0 to 30 percent, but less use was found on steeper slopes. Most cattle use was on slopes of less than 30 percent with little use on steeper areas.

Type edge effect appeared to be important for cattle as well as deer and elk. Shrub density affected deer use positively; elk use little

or slightly positively; and cattle use negatively. Grass utilization was positively related with cattle use, and browse utilization was positively related with deer and cattle use.

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DISCUSSION

DISCUSSION LEADER TOWNSEND: I believe the significance of Mr. Julander's excellent paper is obvious to those who are directly concerned with land management. To the man who has to stand up and say, "Well, this area will be reserved primarily for cattle use or elk or deer use," this type of information is of extreme value.

MR. COTTEL (Texas): I merely wanted to ask how far the deer or the cattle or elk would have to go between areas of water? It seems to me that this is most important and that if the water were a long way away, then I believe you would find a great difference. However, if it is close, I don't think it would have any significance at all.

MR. JULANDER: I think that is correct. In the areas that the cattle grazed, they perhaps did not graze over a half a mile from water. They were relatively well distributed over the area. I think that is the reason we did not get any differences. I am sure if we had longer distances from the water that we would have found very significant differences.

DR. J. P. LOWE (Utah): While I appreciate the fine presentation, I am wondering if you would like to comment further on the intensity of grazing of the three animals that you are talking about?

MR. JULANDER: Well, the intensity of use, no doubt, is very important. Perhaps one reason we did not get more significant differences for elk, was that they were relatively scarce on the area compared with the others. We don't know numbers on these areas—we don't even know cattle numbers because they did not graze the entire season on this particular area.

However, from our fecal counts, cattle made up 57 per cent of the total use; deer made up 26 per cent and elk made up 17 per cent. However, from the signs you could see, we would say it was not overgrazed by deer and certainly not by elk. If we had more pressure from elk use, we would have seen different results, I am sure, with elk.

DR. DAVID KLEIN (Alaska): This certainly is an interesting paper, particularly in the demonstration of relationship between the several species.

In some work that we have done in Alaska with black-tailed deer, we found similar preferences for certain habitat types, and we found that these seasonal variations and preferences for habitat types were related to the quality of the vegetation available in any given area. In other words, as the quality of vegetation became highest in one area during the period of the summer growing season, the deer would move into that area. These changes were usually associated with the progress of the growth of vegetation. As the season advanced with changes in exposure and altitude, a different condition began to exist.

I was wondering if you had been able to relate your studies to quality of the vegetation in the case if habitat preferences for other species involved?

MR. JULANDER: I am sure deer and elk shift around with the vegetation. The deer, in the very early spring, eat grass heavily. Then they forage a good share of the summer on forb vegetation as long as it is green and then, later they turn to shrubs. Therefore, you would expect some shift to shrubs in late season.

We found this to be the case with elk and also with deer. However, we do not have detailed enough studies to explain some of these movements but the deer and elk did shift with the seasons and the forage has a great deal to do with it. Further, the cattle did not shift. They were rather limited in their area.

MR. BROWN (Washington, D. C.): You mentioned the significance of edge affect. Would you care to give an estimate on how far from the edge that this reduction became apparent. How far did the animals have to move from the edge before they would start to move back?

MR. JULANDER: I cannot give you any definite figure on that except perhaps to tell you the depth of some of our types.

A few types were over a mile across and so it would be less than a half a mile from the edge end. The maximum would be about half a mile and so the edge effect was less than half a mile.

MR. MACQUEEN (Oregon): I have a curiosity about access roads in the area, as well as human traffic. Did you find those things in your study of the area and, if so, did they have a measurable influence as to use of the area by deer and elk?

MR. JULANDER: I think perhaps that is true. There was a major road going up through the middle of the study area and we suggested in our text that this, along with the better quality of forage in the steeper area, might have had an effect on the use of the leveler areas and less use of leveler areas by the deer.

MR. ERNEST PAYNTER (Canada). I am interested in the economic aspects of your study. I am wondering if there was any thought, or have you a basis for working out an equation whereby it might be economically sound for the ranchers to change the habitat in some of this area?

MR. JULANDER: I think our results point to some possible indicators we might use in improving habitat for ranchers as well as for big game. Your cattle grazing on leveler slopes indicate that these would be the most logical slopes to improve by reseeding and they could very well do this.

All three classes of animals would benefit by making openings in the timber types. This timber type has little value commercially for wood. We would have to let it not interfere with multiple uses of the area, but as far as the three animals are concerned, we could improve their habitat by making openings in the larger timber types.

SOME RELATIONSHIPS BETWEEN WINTERING MULE DEER AND THE PHYSICAL ENVIRONMENT[1]

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Fundamental to intelligent management of mule deer (*Odocoileus hemionus* (Rafinesque) is an understanding of their basic environmental needs. Research to date appears to have neglected somewhat the less obvious environmental factors of mule deer winter ranges. For example, the micro-climates of various exposures and cover-types have been studied little, as is also true of the spatial distribution and behavior patterns of deer as related to topographic configuration. Knowledge of these complexities assists in explaining why deer occupy one slope or valley and not another nearby; why some food areas are heavily utilized while adjacent ones remain essentially untouched; and why deer are usually not randomly dispersed over the winter range.

The primary objective of this investigation was to assess the effects of both single and multiple elements of a winter-range environment, particularly the physical aspects, on the biological responses of mule deer. An additional objective involved development of a technique for measuring deer activity on a continuous quantitative basis facilitating mathematical evaluation of deer responses to environmental influents.

DESCRIPTION OF AREA

The area of investigation is in the Front Range, northcentral Colorado, eastern-most unit of the Rocky Mountains, approximately 45 miles west-northwest of Fort Collins. Elevations vary from about 7,400 to 9,000 feet. A small permanent stream, Sevenmile Creek, bisects the tract and flows into the Cache la Poudre River, 7 miles southeast of its origin.

Generally, both study area and adjacent regions present an irregular vegetative pattern characterized topographically by acute slope declivities, exposed bed-rock outcrops, talus slides, and loose-soil stones. The physical features of this interrupted surface configuration modify the influence of light, temperature, wind, and precipitation, all factors of particular interest in the investigation.

Climatic regimes are essentially continental and are characterized by long, cold winters and short summers with warm days and cool nights. Persistent winter extremes of low temperature and snow are infrequent. The rather extreme topography has produced a complex

[1]A contribution of the Colorado Cooperative Wildlife Research Unit, Colorado Department of Game, Fish, and Parks, U. S. Atomic Energy Commission, Wildlife Management Institute, and Colorado State University.

of north-facing coniferous timbered slopes and south-facing shrub exposures which are strikingly different in their effects on the local climate.

The Sevenmile Creek study area is approximately 960 acres, and is located in the upper montane formation of the northern coniferous forest biome (Fig. 1). Identifying life forms are needleleaf ever-

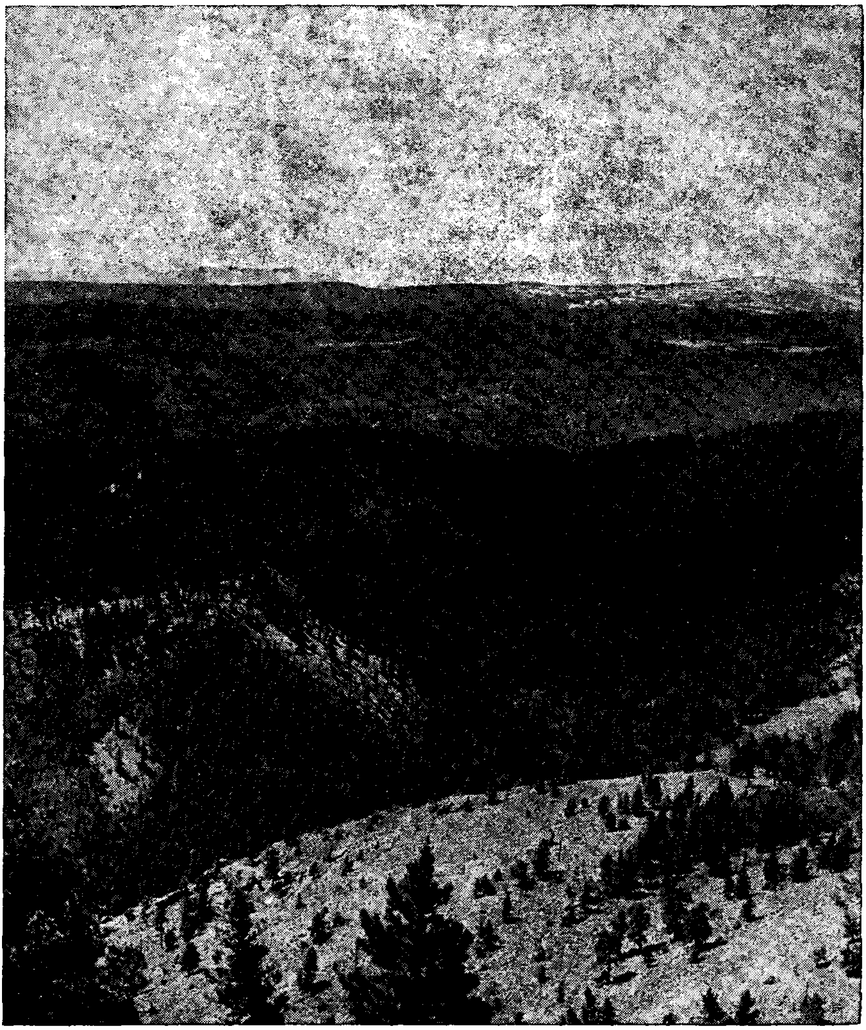

Fig. 1. A portion of the Sevenmile Creek mule deer winter range in foreground, and high summer ranges in extreme background.

green trees, *viz.*, ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), and lodgepole pine (*Pinus contorta*).

Major communities appear as relatively small admixtures of dense to moderately dense coniferous stands, mixed shrubs, and grassy stream-side meadows or deciduous forests.

THE POUDRE CANYON DEER HERD

Deer of the Poudre Canyon area vacate the winter range proper, from 6,000 to 8,500 feet elevation, in late April and early May and begin their ascent to the higher intermediate and summer ranges (Dietz *et al.* 1962). Probably less than 5 to 10 percent of the total wintering herd remain at about 8,000 feet and below throughout the year, but many animals apparently summer on transition ranges at the approximate 8,400- to 8,800-foot level. The greater part of the herd moves to the higher spruce-fir-lodgepole pine zones in the spring and, in late September and October gradually drift back to wintering areas (Dietz *et al., op. cit.*). General observations suggest that during mild autumn seasons deer remain in the high transition regions until a severe storm or accumulated surface snow drives them to lower elevations.

METHODS

Evaluation of the physical environment required measurement of microclimatic elements in four contiguous, dissimilar vegetative-topographic units. Standard Weather Bureau instruments and shelters were located in the approximate geographical center of the intensive study sites. Instruments, where applicable, were positioned at "deer height" (36 inches above ground surface) and serviced five times per month.

A transect of 10 maximum-minimum thermometers, positioned about 132 feet apart, was located on the south-facing exposure extending from slope base to the topographic crest.

Snow depth was determined from a series of transects, consisting of ten stakes each, which were established in the four intensive study locations, as well as on a ridge site and and east-facing slope.

The effect of topographic shading was assessed, employing Tonne's (1955) "horizontoscope." Sunlight duration was determined at specific sun declination values on clear days at selected sample-point locations. Radiation indexes, as functions of slope gradient and aspect, were determined according to methods described by Lee (1962).[2]

[2]Radiation index is the per cent of maximum potential insolation available to a surface during the course of a day, a season, or a year. The solar constant is 2.00 gm-cal/square cm × min (Johnson 1954).

Determinations of slope gradient, aspect, size, and shape were made for each vegetative-topographic type on the 960-acre tract.

Deer behavior patterns were evaluated by pellet-group counts, observations, and measurements of deer-browse utilization.

Circular, 100-square-foot, pellet-group plots were established in a stratified random sample design. Observations of deer were made from a blind or from other concealed vantage points. Appraisal of total deer browse utilization was accomplished by methods outlined by Passmore and Hepburn (1955). Sample plants were selected by the angle-order method according to Morisita (1957).

RESULTS AND DISCUSSION

Topography and Microclimate

Topographic configuration manifests itself in at least two important respects. First, the diversity of the land surface influences the microclimate, causing some areas to be cool and moist and others to be warm and dry. Second, the differences in microclimates are largely responsible for producing an intricate vegetative matrix, which itself, in turn, modifies the microclimate. The effects of these interrelated factors are exerted unevenly in the various habitats and are important in the ecology of terrestrial animals.

Topography

The effects of topography on deer behavior are basically indirect, and include such factors as slope gradient and aspect, size, shape, and orientation of land features, sunlight duration, and incoming solar radiation. In the present study these factors were investigated and results indicated the following:

The mean slope gradient per type for the shrub and coniferous timber areas is 39 and 37 percent, respectively. When slope gradient is weighted on an acreage basis, however, about 75 percent of the total surface area is between gradients 41 and 60 percent.

Shrub and coniferous timber types combined make up about 90 percent of the total horizontal land surface in the area, and this acreage is about equally divided between shrubs and timber. Aspen-grown valleys and grassy-meadows constitute 7 and 3 per cent, respectively. The individual types are generally linear to oblong in shape and oriented essentially in a southwest to northeast direction.

Slope aspect and gradient influence incoming direct radiation. For example, the mean radiation index for the shrub types in winter is 37, while for the coniferous timber types it is 19. On the intensive study area the south-facing exposure and ridge area receive approximately 9 times as much direct sunlight, with clear skies, as the north-facing exposure, and sunrise is later and sunset earlier on this exposure than on any of the other exposures studied.

Orientation of any land mass considerably influences the extent of topographic shading, and consequently incoming radiant energy. If the area drainage was oriented north and south instead of east and west, the vegetative complex as well as many other habitat relationships would undoubtedly be altered because of the influence of topographic features upon incoming radiant energy.

The areas of most intense use by deer during the winter, *viz.*, the shrub, and the open-timber, shrub-understory types, were also those having the longest duration of direct sunlight and the highest radiation indexes.

Topographic shading seemingly was related to deer behavior patterns. For example, during winter the animals sought out direct sunlight, particularly on cold days (0° F. and below). Deer were frequently observed feeding immediately above the "sunshadow" on exposed aspects, and as the sunshadow gradually progressed up-slope, the deer likewise moved up-slope. Also, when the animals bedded down, locations in direct sunlight were often selected, and they moved to sunny locations with the changing shadows. Dixon (1934), Hosley and Ziebarth (1935), Cook and Hamilton (1942) and Cowan (1945) reported similar results. During warm spring days (45° F and above), contrastingly, deer evidenced an apparent negative response to direct sunlight by moving into shaded situations, and continually altered their position to remain in the changing shadows.

Microclimate

Students of relationships between environmental conditions and plant and animal distribution have long recognized the marked differences which occur within areas of restricted size (Allee *et al.* 1949). Environmental differences which obviously exist between adjacent and contrasting habitats in mountainous terrain, and which account for slope differences in vegetation, for example, are related to factors other than broad climatic influences (Shanks and Norris 1950). Potzger (1939) pointed out that microclimate influences the use of certain habitats by terrestrial organisms; and Wolfe *et al.* (1949) suggested that the microclimate in some way affects the behavior of every terrestrial organism every minute of its life.

Severinghaus and Cheatum (1956) stated that the influence of changes in microclimate on white-tailed deer movements touch on one of the least understood relationships of deer to their environment. Yet apart from the influence of gross climatic differences, or other fac-

TABLE 1. MICROCLIMATIC CHARACTERISTICS, SEVENMILE CREEK, 1961-62

Exposure[1]	Lowest minimum air temperature F. 1961	Lowest minimum air temperature F. 1962	Mean hours below 32° F. 1962	Mean hours below 0° F. 1962	Highest maximum air temperature F. 1961	Highest maximum air temperature F. 1962	Radiation index winter	Mean hours direct sunlight 1962	Mean monthly total wind mileage 1961	Mean monthly total wind mileage 1962
North	− 8.0[a]	−17.0[a]	33.4[b]	25.9[b]	80.5	82.0	0	1.32	815	845
South	−11.0	−18.0	20.5	18.9	87.0[c]	87.0[c]	58[c]	10.74[b]	2,879[c]	2,674[c]
Aspen	−12.0	−28.0	16.3	22.3	79.0	83.0	29	8.16	1,027	819
West	− 9.0	−18.0	23.5	23.6	80.0	84.0	43	7.46	1,960	1,912

[1] North—Dense pine-Douglas-fir, north-facing exposure
South—Dense shrub, south-facing exposure
Aspen—Aspen-grown valley
West—Sparse pine-Douglas-fir, west-facing exposure.

[a]—Lowest minimum value
[b]—Longest duration in hours
[c]—Highest maximum value

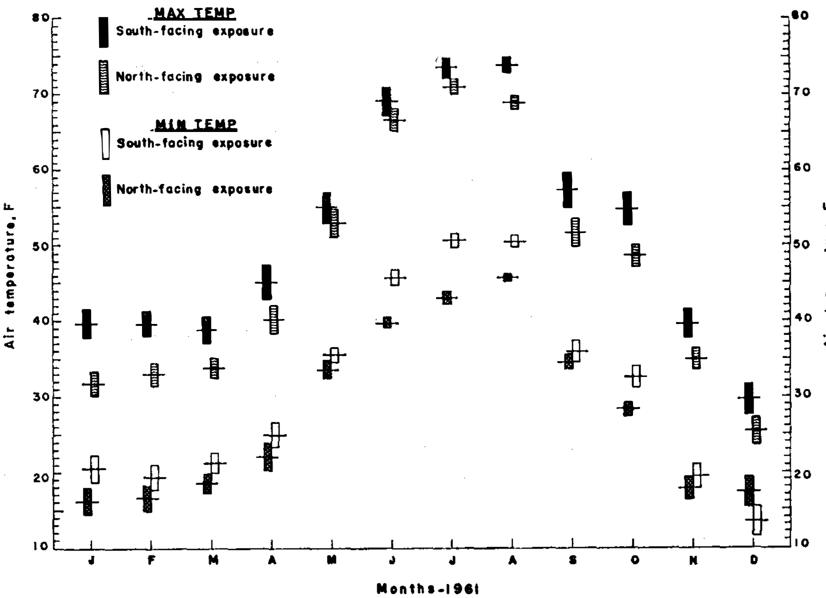

Fig. 2. Comparisons of monthly mean maximum and mean minimum air temperature, Sevenmile Creek. The small vertical rectangles represent 2 standard errors on either side of $\bar{x}$.

tors, the microclimate may be of great importance in their distribution. Certain microclimatic characteristics determined for contrasting exposures on the study area are presented in Table 1 and Figure 2.

Environmental data obtained in this investigation were not mathematically correlated with deer behavior. The requirements for such analysis were not met because methods employed were inadequate to provide continuous, quantative records of deer activity. This was apparent from the beginning of the study and, as a consequence, efforts were initiated to provide a new technique. Such a technique was developed, based on use of photoelectric-cell devices (Loveless *et al.*, 1963).

Air Temperature—Mule deer are homoiothermal and lack an extensive system of sweat glands (Davis, R. W., 1963, personal communication). Hence, they must make certain adjustments to meet extreme variations in ambient temperature. These adjustments may take the form of extended movements, or short movements within the principal habitat; for example, migration, and from exposed sites to the shade of a forest stand, or the reverse.

At Sevenmile Creek, deer activity and movements were associated with air temperature regimes. The general seasonal pattern was as follows:

The first arrival of deer on the winter range in September and October corresponded with a gradual downward trend in air temperature. During the warm (40° to 50° F.) part of the fall season, deer were well distributed over the area, but showed preference, particularly during mid-day, for the cooler, open-timbered types and drainage channels, generally avoiding the warmer exposed sites. In late November and December, with the onset of lower temperatures and increased frequency and duration of sub-freezing periods, use of the warmer south- and east-facing exposures increased, and the deer became more concentrated. This aggregating tendency was especially evident when temperatures declined sharply. Hammerstrom and Blake (1939) reported that white-tailed deer in Wisconsin concentrated with lowered temperatures, and suggested that 20° F. seemed to be the critical level triggering this phenomenon. On the Sevenmile area the temperature level which triggered obvious concentrations of deer appeared to be in the range from about -10° F. to 5 or 10° F., but humidity and wind were also important factors.

During most of the winter deer used the open-timbered, west-facing, and the shrub-covered, south-facing, exposures more than the heavy-timbered north exposure or the aspen-grown valley. The first two locations had significantly ($\alpha = .05$) higher maximum, minimum, and mean air temperatures and shorter durations of sub-freezing and below-zero temperatures than the last two locations. Furthermore, the area of greatest use on the south-facing slope—the upper portion—(Table 2), was significantly warmer than the lower part of the slope. The south- and west-facing exposures also received more incoming solar radiation than the other two aspects, and more direct sunlight, which in large measure explains the higher temperatures.

TABLE 2. COMPARISON OF PELLET GROUPS FROM UPPER AND LOWER SLOPE TRANSECTS, DENSE SHRUB, SOUTH-FACING EXPOSURE, SEVENMILE CREEK, 1961

		frequency = 0, 1, and 2 groups/plot			frequency = 3 or more groups/plot			
Plot location	Mean pellet[1] groups/plot	ob.	ex.	chi-square	ob.	ex.	chi-square	Total
Lower-slope transects	3.13	19.00	14.23	1.5989	18.00	22.77	0.9992	37.00
Upper-slope transects	7.71	6.00	10.77	2.1126	22.00	17.23	1.3205	28.00
Total		25.00	25.00		40.00	40.00		65.00

$\Sigma(o - e)^2/e = 6.03^*$
Tabular chi-square = 3.84 (α = .05 1 d.f.)

* Mean number of pellet groups per plot from upper- and lower-slope transects are significantly different.

[1] Includes all accumulated pellet group depositions.

In both 1961 and 1962 deer began vacating the study area in April, the month when pronounced upward trends in air temperature began. Mean temperatures in April were consistently in the 30's, but maximums in the 60's were not uncommon. In the early morning, during late March, April, and early May, when it was sufficiently light to see the animals, they were actively feeding in the browse areas, but by 0730 or 0800, when temperatures increased to 45 or 50° F., the deer either bedded down in shaded situations, or otherwise moved into the shade of forest stands. In the late afternoon, with a decrease in temperature, they again moved out onto the open slopes. These observations further suggested that during the warm spring period much of the feeding activity was at night, while in winter the reverse of this was probably the case.

Although deer movement and activity patterns as previously discussed were related to factors other than air temperature, results indicated that deer noticeably responded to fluctuations in temperatures, particularly sudden and sharp decreases or increases. Further evidence suggests that deer moved from location to location in their principal winter habitat seeking out the most "comfortable" temperature zones. At Sevenmile this zone in winter was about 15° to 45°F. Taber and Dasmann (1958) stated that the favorite temperature zone of mule deer in the northern coastal range of California appeared to be 55° to 65° F.

Movements from season to season were associated with air temperature, and high air temperatures, coupled with other factors, may explain in part the scarity of deer on the study area during the summer. Thus, heat as well as cold induces reactions by deer. During cold weather they respond by moving to warmer exposures, and to the warmest sites on these exposures, or to locations where temperatures are less severe, other factors equal. Nocturnal activity is seemingly reduced during extremely cold periods and, as nights become colder, feeding activity is more pronounced during the warmer daylight hours.

Air temperature on the exposures studied was primarily a function of air mass as influenced locally by aspect, gradient, and the reflectivity and conductivity of soil surfaces as related to sunlight duration and incoming solar radiation. The vegetative cover also apparently affected air temperatures to a certain extent.

Relative humidity—Relative humidity is an artificial ratio and, as such, does not exist in the environment. Humidity, on the other hand, or the amount of atmospheric moisture, plays an important role, influencing the activities of organisms and controlling their distribution (Odum 1953).

Within a given air mass, relative humidity shows an obvious negative correlation with air temperature. Thus, if animal behavior is associated with one element, it must be associated with the other, irrespective of whether or not the reaction is induced in a cause and effect relationship.

At Sevenmile, low relative humidities were generally associated with high air temperatures, but moist maritime air masses in winter did, on occasion, produce saturated, or near saturated, atmospheric conditions accompanied by low temperatures.

Because of the generally negative correlation between air temperature and relative humidity, it is logical to assume that, essentially, responses of deer to high temperature were associated with low relative humidity and responses to low temperature with high humidity. Reduced activity was evident in the former situation, while increased activity was apparent in the latter. A reduction in activity was also noted, however, during those rather infrequent periods when air temperature was low (25° F. and below) accompanied by low humidity (20 percent and below). Thus, when atmospheric moisture is low and the duration of such lows increases progressively (fall and spring), deer activity declines; but an increase in moisture (winter) is accompanied by increased activity. Prevailing temperatures are notably associated with this pattern, and relative humidity does not act independently of other weather elements in determining mule-deer behavior.

Precipitation—At Sevenmile a sparsity of precipitation was characteristic, in common with the major portion of the range occupied by mule deer in North America (Hill 1956). For example, in 1961 the total annual precipitation on the Sevenmile area varied from 18.52 inches on the north-facing exposure to 28.31 inches on the south-facing exposure. Most of the recorded precipitation fell in the form of snow.

Deer were frequently observed during both light and heavy snow storms, but showed no discernible reaction. Heavy snow storms accompanied by high winds and low temperatures (10 to 15° F. and below) induced a response however, and deer were rarely observed in exposed situations during those periods.

Depth of ground-surface snow induced perhaps more response in deer than any other weather element with the possible exception of interacting air temperature and atmospheric moisture. Locations intensively used by deer, *viz.*, south- and east-facing shrub types and open-timber, shrub-understory types, had significantly ($\alpha = .05$) less surface snows than the other exposures compared. The deepest surface snows were recorded on the north exposure and in the aspen-grown valley, areas of less intense use by deer.

Snow depth also appeared to be the reason deer moved to lower portions of the study area earlier in 1962 (January) than in 1961 (March). During 1961, snow depth was considerably less and more browse was available at the higher elevations.

Ground surface snow of 10 to 12 inches impeded deer movement, especially of yearlings, and depths of 20 to 24 inches essentially precluded their use of an area, e.g., north-facing, timbered exposures, and seriously hampered or prevented locomotion.

Excessive snow depths at Sevenmile were apparently associated with the animals' tendency to concentrate. This was particularly evident in January 1962, when a heavy snow storm occurred accompanied by temperatures of 25 to 30° F. below zero. These conditions caused deer to concentrate on the extreme upper portions of the south-facing exposures. On the morning following the storm, 27 deer beds were counted on the upper portion of one slope, an area less than 0.5 acre, where on previous occasions no more than four or five beds were ever observed. Climatic data showed that this particular site was one of the "warmest" on the area, and also had the least amount of ground-surface snow.

Allee *et al.* (1949) stated that crowding of animals may be important to group survival, and it has been demonstrated that air temperatures are modified in certain microhabitats by animal aggregations. Swift (1941), Cook and Hamilton (1942), Cowan (1950), and Longhurst *et al.* (1952) suggested that the tendency for deer to concentrate is a response to environmental stimuli, and among these, snow is of considerable importance. In contrast, however, Darling (1937) mentioned that red deer in the Scottish Highlands concentrated in groups a few days prior to a snow storm, and deep snow was not the direct causative factor, and Hammerstrom and Blake (1939)

TABLE 3. MULTIPLE COMPARISONS OF TOTAL DEER BROWSE UNITS FOR VEGETATIVE TOPOGRAPHIC TYPES, SEVENMILE CREEK, 1962

Exposure	No. plants sampled	Total deer browse units in sample	Comparisons	Lower and upper confidence limits on total differences	
				LL	UL
Dense pine, Douglas-fir north-facing exposure (1)	120	23	1 vs. 2	−703.6	−1,285.4*
Dense shrub south-facing exposure (2)	120	1,007	1 vs. 3	132.8	−266.0
			1 vs. 4	−443.9	−929.3*
Aspen-grown valley (3)	120	85	2 vs. 3	418.2	1,437.6*
			2 vs. 4	−162.3	779.3
Sparse pine, Douglas-fir west-facing exposure (4)	120	709	3 vs. 4	−126.6	−1,112.2*

* Confidence limits which do not bracket zero are significantly different at the 5 per cent level.

TABLE 4. COMPARISON OF PELLET GROUPS FROM THE SOUTH-AND WEST-FACING EXPOSURES, SEVENMILE CREEK, 1962

Plot location	Mean pellet groups/ plot[1]	Frequency = 0 groups/plot			Frequency = 1 group/plot			Frequency = 2 groups/plot			Frequency = 3 or more groups/plot			Total
		ob.	ex.	chi-square	ob.	ex.	chi-square	ob.	ex.	chi-square	ob.	ex.	chi-square	
South-facing exposure	0.46	43	49.86	0.94	20	12.47	4.54	2	3.12	0.40	2	1.56	0.12	67
West-facing exposure	0.24	53	46.14	1.02	4	11.53	4.91	4	2.88	0.43	1	1.44	1.34	62
TOTAL	—	96	96.00	1.96	24	24.00	9.46	6	6.00	0.84	3	2.00	1.47	129

$\Sigma (o - e)^2/e = 13.73$*

Tabular chi-square = 7.81 ($\alpha = .05$ 3 d.f.)

* Mean number of pellet groups per plot between exposures is significantly different at the 5 per cent level.

[1] Total pellet group counts for the north-facing exposure and aspen-grown valley was 1 in 62 plots, and 2 in 72 plots respectively.

asked, "Do deer band together for reasons so old phylogenetically that they can no longer be traced?"

Surface snow frequently covers much of the otherwise available food for deer. This was particularly evident on the north aspect of the intensive study area in the late winter of 1962, and to a lesser degree on the other aspects. Approximately 50 percent of the shrub species on the north exposure and in the valley were covered by snow during much of the winter, while on the west exposure 20 to 25 percent were covered, and on the south and east exposures less than 15 per cent. These relationships between food availability and differential use intensity are reflected partly by data in Tables 3 and 4. In 1961 the availability of browse on the ridge area was similar to the condition on the south exposure, but during 1962 most of browse on the ridge was covered by snow from January through early April. Snow depth was probably the principal deterrent in winter to utilization of forage by deer. Hosley (1956) says that in the northern portion of the white-tail's range depth and duration of winter snow cover determine the animal's ability to reach food. Smith (1954) reported similar results working with big game in Idaho, and Cowan (1947) stated that 6 inches of snow altered the types of food consumed by deer in Canada. It is generally concluded that snow is an integral part of the physical environment of mule deer, and that snow depth is associated with certain reactions of the animals.

At Sevenmile, snow depth was most influenced by slope aspect, wind, and air temperature, the latter importantly related to topographic shading and aspect.

Wind—Wind velocity or direction apparently induces little reaction in deer except during very cold weather, and the animals seldom showed any noticeable response. On days when winds were gusty, there seemed some tendency toward increased movement or activity while feeding, or bedded down. There was, however, a noticeable relationship between deer activity and high wind velocity (25 miles per hour and above) on days when the temperature was low (15°F. and below). Under these conditions deer generally avoided the open browse slopes and other exposed situations, and sought shelter on the lee side of rock outcrops, in timber, or in drainage channels. This reaction was apparently induced by the cooling effects, or "chilling" produced by wind currents. Gates (1962) has shown that convectional currents disturb the layer of warm air which surrounds the surface of both plants and animals thereby lowering the temperature of these surfaces. This perhaps essentially explains the reaction of deer to high winds accompanied by low temperatures.

Exposures having the greatest over-all use by deer on the area were

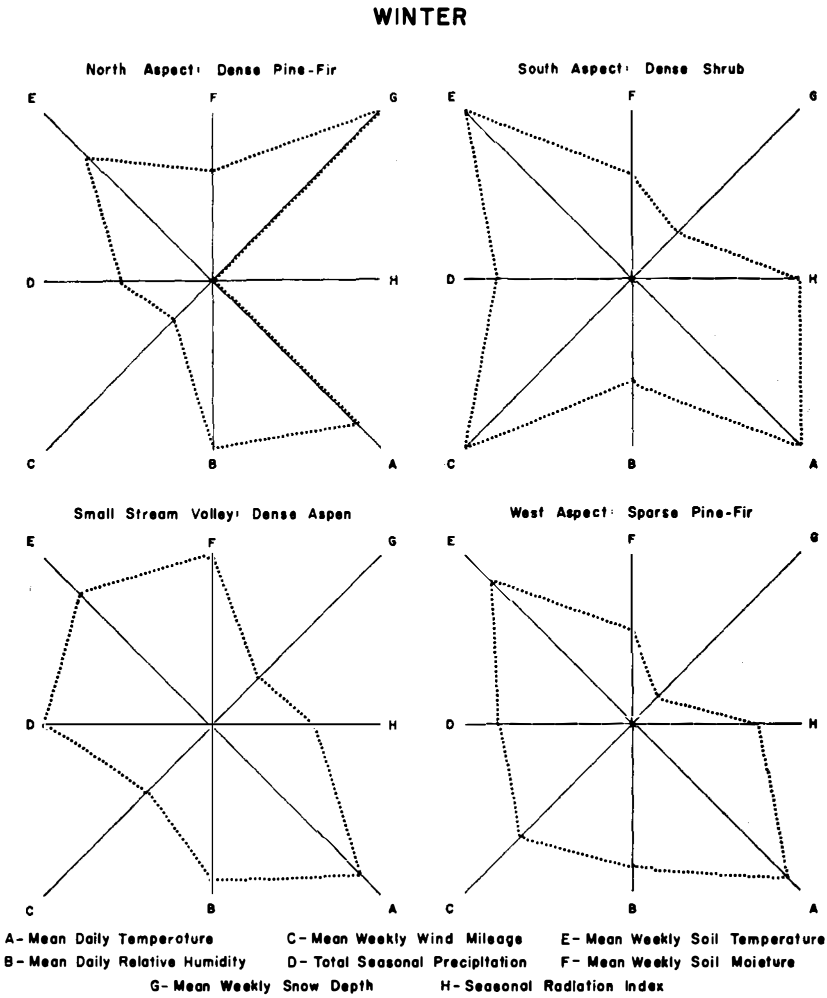

Fig. 3. Winter microclimate factor complex, Sevenmile Creek, 1961. Distances from the intersect along the lines representing each microclimatic element are relative to the highest value recorded for that element on a specific exposure. For example, the highest mean soil temperature (E) occurred on the south aspect, and the distance along line E from the intersect for the other exposures is relative to that depicted for the south aspect.

also those where wind velocities were highest. The exception to this general pattern was periods of gusty wind and unusually low temperature, when deer moved into the aspen-grown valley and other timbered areas. Wind velocities were affected to a considerable extent by vegetative cover, as well as by slope exposure and prevailing direction.

TABLE 5. COMPARISON OF OBSERVED PELLET-GROUP FREQUENCIES WITH THEORETICAL POISSON PROBABILITIES, DENSE SHRUB, SOUTH-FACING EXPOSURE, SEVENMILE CREEK, 1961

No. pellet groups/plot (X)	Observed frequencies (n_t)	Poisson probability (N_{pt})	Theoretical frequencies $(n_t - N_{pt})^2/N_{pt}$
0	14	0.40	462.40
1	4	2.48	0.93
2	7	4.64	1.20
3	5	8.73	1.59
4	2	11.21	7.57
5	6	11.35	2.52
6	6	9.70	1.41
7	4	7.73	1.80
8	3	4.52	0.51
9	2	2.56	0.12
10	2	1.38	0.28
11–19	10	0.31	302.89

$\bar{X}$ = 5.11/plot $\Sigma(0 - e)^2/e = 783.2^*$ (10 d.f.)
N = 65 Tabular chi-square = 18.3 (α = .05)
* Observed frequencies are significantly different from the Poisson distribution.

CONCLUSIONS

Significant differences ($\alpha = .05$) in microclimatic elements, evident in Fig. 3, and intensity of deer use (Table 4) were demonstrated between the four contiguous food-cover types studied intensively. Microclimatic differences were principally manifestations of topographic influences and these various microclimates were unquestionably critical factors in producing evident dissimilarities in the vegetative matrix.

Deer behavior patterns in winter were prominently associated with a complex of interrelated factors, but seldom did the reactions of the animals appear to be induced by independent elements acting alone. Of the physical environmental factors studied, deer response seemed to be most closely correlated with high air temperature and low atmospheric moisture, low air temperature accompanied by high winds or high atmospheric moisture or both, presence or absence of ground-surface snow, and the duration and intensity of direct sunlight. The abundance and availability of preferred browse plants, plus the interspersion of areas where such plants occurred, were also decisive with respect to deer behavior and contributed substantially to the animals' apparent non-random spatial distribution. Data in Table 5 show the non-random spatial distribution of pellet groups which occurred in a browse type on the study area, and results are similar to those obtained from tests of randomness in heavy and sparse timber types.

At Sevenmile, the composition, size, shape, and juxtaposition of the vegetative-topographic facets, plus the kinds of associated microclimates, are undoubtedly relevant to the maintenance of what is seemingly a healthy, stable, mule deer population.

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DISCUSSION

DISCUSSION LEADER TOWNSEND: I believe that these types of studies are always interesting. I noticed that several of you have been engaging in research along that line during the past few days and it has been interesting to watch, especially by those of us who have been conservative and cannot do it ourselves.

I would like to point out again the information developed here by Dr. Loveless in his study is of not only interest but of extreme importance to the land manager, the person who has to know what the uses are and what he has on the land to manage.

DR. A. DEVOS (Ontario): I first of all would like to compliment Dr. Loveless for his very excellent pains in connection with this paper, and I would like to point out that a wildlife biologist should look for environmental variables.

I would now like to ask him whether he has paid any attention to the physical condition of snow—as to its influence on deer movement and, secondly, at what levels he took information about wind velocity.

DR. LOVELESS: All of the instrumentation was placed at what we called deer height, at about 34 inches above the ground surface. We did not obtain records at bedding level.

We did classify snow with respect to crust, but this is as far as we went with it and throughout the study we almost never had crust conditions that would support deer. We did have crust conditions that would have supported some of the other smaller mammals.

MR. GILBERT HUNTER (Colorado): I know this herd well, as well as the range conditions, and knowing a little something about the study, I think there was a very interesting point brought out which I do not quite understand.

In the paper, you will find that the rainfall or snowfall, call it what you want, but generally snowfall in Colorado, amounted to 18 inches in the forest areas as compared to 28 inches in the browse cover. I don't quite understand that. You would naturally think it would be heavier in the forest area rather than in the browse area. I wonder if you will explain that?

DR. LOVELESS: Our records showed there were approximately 10 inches more in the browse types as compared to the timber types. Part of this was instrumentation and part was sampling error. I think it was principally due to crown intercept in the timber types, however.

The thing which I think is important here is not so much the total amount of precipitation but the amount of effective precipitation.

In the browse type with the sun in the South, this 28 inches of precipitation is not very effective. However, in the final analysis, I think it is primarily a crown intercept of the trees.

CHANGES IN WILDLIFE HABITAT COMPOSITION FOLLOWING BRUSH CONTROL PRACTICES IN SOUTH TEXAS[1]

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Most South Texas rangelands are covered with varying degrees of brush. Although this brush usually reduces the carrying capacity for domestic livestock, it provides suitable habitat for such big game animals as white-tailed deer, javelina, and wild turkey. However, since domestic animal production is reduced on dense brushlands, many landowners practice some form of noxious plant control.

Brush composition in the South Texas area is complex; it is not uncommon for as many as eight or ten species to make up the plant composition commonly referred to as "chaparral." Since most species differ in physiological responses to herbicides, chemical treatment of brushlands is seldom completely successful. Too often control of one species releases another more noxious one. Therefore, widespread use of such mechanical brush control measures as root plowing, chaining, shredding, etc. is practiced.

It has been estimated that prior to 1958, over 9,600,000 acres of South Texas brushlands had been treated for brush control (Carter, 1958) and many thousands of acres of brush have been cleared each year since that time. Until recently, little thought was given to the effects of the large-scale brush control treatments on wildlife populations and habitat. Lehmann (1960) proposed methods and techniques for incorporating brush control practices with game management objectives. The effect of brush control on the diet and movements of game populations has been studied by Davis *et al.* (1962) and Davis and Spicer (1963)

The effects of brush control on wildlife populations varies with the environmental conditions. Goodrum and Reid (1956), Reid and Goodrum (1957), and Goodrum (1960) reported brush control to be detrimental to some forms of wildlife. Halls and Crawford (1960) found the most desirable deer ranges in areas of disturbance in the forest of Arkansas. In California, Biswell *et al.* (1952) found mule deer to be four times more abundant on brush-controlled areas than on untreated ranges.

Each game habitat is desirable or undesirable in relation to the combination of plant species present. Each plant species in the habitat responds to brush control pratices in a different manner. Therefore,

[1]This paper is contribution number 88, Welder Wildlife Foundation, Sinton, Texas.

the game manager may actually manipulate the relative amounts of various plants by using different "control" techniques. The field is no longer one of "brush control" but one of habitat manipulation or "brush management."

The South Texas area offers a unique challenge to wildlife workers. The flora is especially rich, containing more than 1300 species (Jones *et al.,* 1960) of flowering plants of tropical and subtropical origin (Gould and Box, 1959). Plant production is relatively high, with seasonal peaks in the spring and in the fall (Box, 1960). Distinct plant communities occur in relation to the soil types of the area (Box, 1961). The great diversity of habitats and available organisms to fill them present ideal conditions for evaluating the effects of brush manipulating techniques.

In general, brush-control practices change the wildlife habitat in two ways: by altering the composition, height and density of plant cover, and by changing the relative availability of food plants. Almost all mechanical brush control methods used in South Texas totally destroy cover for big game unless blocks or strips are left specifically for cover purposes. However, regrowth of treated plants begins almost immediately, and within five to fifteen years, cover is generally adequate for wild animals.

Food availability is changed in several ways. On areas where the soil has been severely disturbed, such as by root plowing or bulldozing, the early successional stages are filled with forbs and annual plants which offer increased seasonal production. Animals tend to concentrate on such areas where the weedy plants are young. Likewise, resprouting of brushy species provides palatable browse which is easily accessible.

Since brush species respond differently to treatment, the relative composition of browse plants is affected differently by each control treatment. This change in composition is one of the most important changes in the habitat for game animals.

The extent to which brush control alters composition was demonstrated by a study on the Welder Wildlife Foundation near Sinton, Texas. In 1960, brush-control plots were established on two soil types on the Welder Refuge. Several areas, each approximately 80 acres in size, were cleared with a root plow on Medio Fine Sandy Loam and on Victoria Clay. The blade was drawn behind a crawler tractor and held approximately 8 to 12 inches below the soil surface. In 1961, portions of the root plowed areas were raked with a large root rake drawn behind a crawler tractor in an attempt to pull the remaining shrubs from the soil.

Fifteen 100-foot line intercepts were established on each area that

TABLE 1. RELATIVE PERCENT COMPOSITION OF WOODY SPECIES ON TWO SOIL TYPES FOLLOWING BRUSH CONTROL PRACTICES IN SOUTH TEXAS

	Medio FSL			Victoria Clay		
Plant	No Treatment	Root Plow	Rake & Root Plow	No Treatment	Root Plow	Rake & Root Plow
Acacia farnesiana	2.0	4.3	10.6	1.0	3.7	3.7
Acacia rigidula	18.5	5.3	3.8	21.0	7.4	13.7
Acacia tortuosa	10.0	8.2	3.8	1.1	2.7	7.5
Berberis trifoliolata	T	T	T	19.9	46.2	11.2
Calliandra conferta	1.0	49.3	47.5	3.3	4.6	12.5
Celtis pallida	7.4	5.3	6.5	1.1	9.2	25.0
Condalia sp.	5.0	1.0	12.5	19.3	8.2	6.2
Diospyros texana	4.0	1.0	2.3	1.9	T	1.2
Prosopis glandulosa	44.5	2.9	4.1	1.1	3.7	12.5
Zanthoxylum fagara	3.0	2.8	4.6	1.6	12.9	6.2

had been root plowed, root plowed and raked, and on check areas that had not been treated. Data from the intercepts were used to compare the relative abundance and availability of the major woody plants on areas that had been subjected to each type of control.

The Medio Fine Sandy Loam site had been a live oak savannah (*Quercus virginiana*) with the interspaces between the live oaks filled with chaparral approximately six feet tall. Ten species of brush plants were present in the chaparral complex. Mesquite (*Prosopis glandulosa*) was the dominant shrub, comprising 44% of the total vegtation (Table 1). Mesquite, blackbrush (*Acacia rigidula*), and screw bean (*Acacia tortuosa*) made up approximately two-thirds of the total brush cover.

Following root plowing and raking, none of the three most abundant shrubs contributed as much as 5% to the total composition. Other species, rather obscure in the original composition, increased greatly. False mesquite (*Calliandra conferta*) made up almost half of the woody cover on the brush controlled areas. False mesquite, huisache (*Acacia farnesiana*), and lote (*Condalia* sp.) increased from a total of only 8% in the original vegetation to almost two thirds of the composition following root plowing and raking.

Several woody species maintained essentially the same percentage composition before and after root plowing. For instance, varying amounts of granjeno (*Celtis pallida*), Mexican persimmon (*Diospyros texana*), and prickly ash (*Zanthoxylum fagara*) existed under different treatments, but the differences between treatments were not statistically significant.

Cactus densities are generally increased by mechanical brush control techniques. Both tasjillo (*Opuntia leptocaulis*) and prickly pear (*Opuntia lindheimeri*) were present on the Medio Fine Sandy Loam plots. Tasajillo increased 600% after root plowing (Table 2). Apparently the original plowing broke many of the older plants and scat-

TABLE 2. REACTION OF TASAJILLO (*OPUNTIA LEPTOCAULIS*) TO BRUSH CONTROL PRACTICES ON MEDIO FINE SANDY LOAM.

	Check Plot	Root Plowed	Root plowed & raked
Density	0.2	1.4	0.4
% increase in density	—	600.0	100.0
Relative % Composition	0.4	19.8	4.1

tered them over the area. The subsequent raking killed some of those already established.

Prickly pear was not present in sufficiently large quantities to obtain an adequate sample with the sampling method used in this study. However, observations of other South Texas brush-control projects showed that prickly pear may be scattered by root plowing.

The Victoria Clay site was dominated by a Chaparral-bristlegrass Community. Blackbrush, lote bush, and agrito (*Berberis trifoliolata*) comprised approximately two-thirds of the composition (Table 1) before control practices. After control, blackbrush, mesquite, false mesquite, and granjeno comprised about two-thirds of the vegetation on the clay sites. Agrito and prickly ash increased in relative abundance after root plowing only, but decreased where the root-plowed area was raked. The root plow loosened the plants in the soil, but they apparently re-established themselves unless plowing was followed by raking.

There was a significant interaction between brush species and soil types. Over 98% of the mesquite plants were killed by brush control practices on the fine sandy loam while only 18.7% and 81.2% were killed by root plowing, and root plowing and raking, respectively, on clay soils (Table 3). Granjeno populations were reduced by three-fourths or more on sandy soils, but actually increased on clay soils.

Some of the differences in species response may be explained by the soil types on each site. Victoria Clay is a grumosol, primarily composed of montmorillonite. When moisture is available, the clay tends

TABLE 3. PERCENT REDUCTION IN DENSITY OF WOODY SPECIES ON TWO SOIL TYPES IN SOUTH TEXAS FOLLOWING BRUSH CONTROL.

	Medio Fine Sandy Loam		Victoria Clay	
Species	Root Plowed	Root Plowed & Raked	Root Plowed	Root Plowed & Raked
Acacia farnesiana	(27.3)[a]	(57.1)[a]	0.0	25.0
Acacia rigidula	92.6	95.0	91.3	86.7
Acacia tortuosa	84.2	91.3	28.5	42.8
Berberis trifoliolata			74.8	95.6
Calliandra conferta	(750.0)[a]	(941.4)[a]	65.9	31.8
Celtis pallida	89.2	78.9	(105.8)[a]	(241.2)[a]
Diospyros texana	95.0	95.0	—	84.0
Prosopis glandulosa	98.7	98.8	18.7	81.2
Zanthoxylum fagara	84.6	69.2	86.5	34.8

[a] Numbers in parenthesis indicate a percent increase in density.

to stick to the plant roots and such resistant species as mesquite may survive. On the other hand, the Medio Fine Sandy Loam is easily shaken from the plant roots and the treated plants are more easily killed.

Screw bean and huisache increased greatly on sandy soils after control, but were either reduced in abundance or exhibited no change when control was attempted on clay soils. Observations of brush control projects in the local area showed that huisache was usually the dominant brush species on old root-plowed areas. Evidently, huisache seed can lie dormant for many years and sprout when the soil has been disturbed.

Mexican persimmon, blackbrush, prickly ash, and agrit were reduced in density on both soil types by plowing and raking. However, their reaction to treatment was essentially the same for both soil types.

Data from this study show that many individual brush species do not respond the same to similar treatments on different soil types. Likewise, plants of different species on the same soils will differ in response to various treatments. The combination of the dozen or more mechanical brush-control practices now in use in South Texas with the innumerable soil types present offer possiblities for the game manager to manipulate the habitat to obtain the type and density of browse species he desires for the game population concerned.

Numerous observers have reported deer moving into brush-controlled areas to feed (Davis *et al.*, 1962, 1963). Preliminary results from experimental brush control plots on the Welder Wildlife Refuge indicate that deer use areas controlled by different methods at different times of the year. For instance, areas where the soil has been disturbed are used most heavily when the weedy plants are in the young and tender stages. Therefore, newly root-plowed areas offer a good source of seasonal feed for a deer herd. On the other hand, when the herbaceous plants are dry or dormant, deer prefer areas that have been cleared by chopping or shredding. The large shrubs have been reduced in height and there is an abundance of fresh regrowth for the animals.

Brush control is an established range improvement practice in South Texas. The land is almost totally privately owned, and the owners must make a profit from their ranching operation. Therefore, brush control is likely to increase rather than decrease in the future.

Brush removal affects game populations through change in cover and food availability. Research must answer the questions of the amount and kind of both food and cover that is necessary for the maintenance of optimum wildlife populations. Systems of brush management can be designed that will allow for rotational control to provide adequate regrowth for cover. Brush-control methods can be selected that will yield the best possible combination of food and cover plants on each soil type. Both the rancher and the game manager must think in terms of a brush-management program other than brush eradication. With proper research information and advanced planning, brush ranges may be managed for increased yields of both wild and domestic animals. The problem is simply one of keeping the correct successional stages present in the desired proportions and distributions.

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DISCUSSION

MR. CHARLES WALLMO (Arizona): You suggest that there are benefits in terms of food for deer and detriments in terms of cover as a result of brush clearing. Presumably there are patterns and percentages that would be most desirable and also most desirable time sequences if these food benefits are lost in time.

Can you make any suggestions regarding desirable patterns and desirable time sequences of treatment?

MR. BOX: We have started some preliminary studies on just this thing but we do not have data on it as yet insofar as the length of time it takes for these plants to regrow, the patterns to develop, etc. However, there is a very definite relationship in connection with all of this.

We know that using certain types of control, where you simply knock the brush down, such as shredding, roller chopping and so on, we get an immediate regrowth. My idea is to work this into some range management practice where we can actually rotate our brush control in order to have open spaces for deer. This is, in effect, the thing I talked about earlier—to have some food available low on the ground to keep the deer happy. Then, in 15 years, we can control the areas that are left and also, by that time, some of these other plants will have grown back.

I think it is a matter of understanding the principle well enough to know when to control plants and when to leave them for cover purposes. As I say, we are just starting these studies and I have not received the information on it as yet.

VICE CHAIRMAN TOWNSEND: I would like to make one small comment on this paper.

It is extremely interesting to me, being in the business of multiple use and land management, that we have come from the point of brush eradication to brush treatment when we found we could not kill all of it. Now we are apparently getting down to business with brush management. It is very heartening to me and I am sure to many of us here, that this type of research is being carried on. Of course, it is certainly necessary.

ELK AND DEER HABITAT USE OF A PINYON-JUNIPER WOODLAND IN SOUTHERN NEW MEXICO[1]

HUDSON G. REYNOLDS

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Pinyon-juniper woodland is valuable winter, and sometimes year-long, range for elk, deer, and livestock in Arizona and New Mexico. This woodland is also found in Colorado, Utah, and Nevada. Total acreage amounts to about 74 million acres (U. S. Congress, 1936). Maintenance and improvement of productive capacity of this woodland can greatly benefit both game and livestock.

Within the recent history of livestock grazing in Arizona and New Mexico, juniper has greatly thickened and even spread into some adjacent grasslands (Parker, 1945). Stockmen have been duly concerned about this increase and spread. As a result, pinyon-juniper clearing techniques, such as cabling, dozing, burning, and hand-chopping have been rather widely used to restore grasslands (Cotner, 1963). From two- to five-fold increases in herbaceous understory valuable to livestock have often resulted from clearing (Reynolds, 1959).

Questions are often raised as to how pinyon-juniper clearing for livestock affects big-game habitat, what specific treatments might be most beneficial to big game, and if some compromise in treatments would be desirable.

This is a preliminary report on some major habitat uses of a pinyon-

[1]This preliminary report outlines progress on a cooperative study of the U. S. Bureau of Sport Fisheries and Wildlife, the New Mexico Game and Fish Department, and the Rocky Mountain Forest and Range Experiment Station, and the Gila National Forest, U. S. Forest Service.

[2]In cooperation with Arizona State University. General headquarters is at Fort Collins, Colorado, in cooperation with Colorado State University.

juniper area in southern New Mexico by deer and elk. From current findings, management implications are proposed as to how livestock range and game habitat improvement practices might be coordinated for better overall land use.

STUDY AREA

The study is located on the Fort Bayard Administrative Site of the Gila National Forest near Silver City in southern New Mexico. This area is about 3 miles wide and 6 miles long. Elevation ranges from 6,000 to 7,000 feet. Since 1870, annual rainfall has averaged 18.67 inches, with annual variation from 5.7 to 31.2 inches.

Topography is broken by numerous drainages, and varies from fairly level benchlands to small knolls. Numerous permanent springs are well distributed over the area. At the higher elevations, dense stands of pinyon-juniper and shrubs are characteristic; at intermediate elevations, the tree canopy is more open and there is more perennial grass in the understory; at the lower elevations, trees and shrubs are confined largely to ridgetops, and fairly open grasslands extend along the drainages.

The Fort Bayard Administrative Site was originally established as a military reservation in 1869. Continued, yearlong livestock grazing gradually deteriorated the area. Extensive corrective and restorative actions were taken in 1937, such as excluding all livestock, except for a few pack and saddle animals. In 1941, the U. S. Forest Service was assigned administrative responsibility for the area. Since then, light grazing by horses has continued.

DATA COLLECTION

Data on accumulated pellet groups of elk and deer, topography, and vegetation characteristics were obtained on a grid of 16 sample areas per section. At each sample area, density of trees and shrubs was determined on 1/10-acre, circular plots. Production of herbaceous understory was estimated on four transects of 1 by 12 feet in cardinal directions about the center of the sample area. Exposure was noted as a compass bearing, and slopes were measured with an Abney level. Accumulated pellet groups were counted on four 25- by 2-foot transects overlying the herbage transects. Because of limitations on the interpretation of accumulated pellet groups, conclusions with regard to pellet group differences are restricted to major relative and general comparisons of habitat use.

VEGETATION RELATIONS

The main trees[3] in the study area are pinyon, *Pinus edulis* Engel.; alligator juniper, *Juniperus deppeana* Steud.; wavyleaf oak, *Quercus*

TABLE 1. RELATIONS AMONG NUMBERS OF TREES, SHRUBS, PERENNIAL GRASSES, AND FORBS, AND DEER AND ELK PELLET GROUPS

Trees No. per acre	Shrubs No. per acre	Perennial grasses and forbs Pounds per acre	Animal class Average pellet groups per plot: Deer	Elk
0–50	42	280	2.4	1.4
51–100	89	180	6.6	2.1
101–150	122	175	7.1	3.3
151–200	137	120	6.9	3.6
201–250	108	90	3.9	2.1

undulata Torr.; and Utah juniper, *Juniperus osteosperma* (Torr.) Little. Important shrubs are birchleaf mountainmahogany, *Cercocarpus betuloides* Nutt.; Wright silktassel, *Garrya wrightii* Torr.; skunkbush, *Rhus trilobata* Nutt.; and wavyleaf oak. Most abundant perennial grasses are blue grama, *Bouteloua gracilis* (H.B.K.) Lag.; sideoats grama, *Bouteloua curtipendula* (Michx.) Torr.; black grama, *Bouteloua eriopoda* Torr.; and vine-mesquite, *Panicum obtusum* H.B.K. Numerous species of forbs are also found on the area.

There are important interrelations among the various classes of vegetation (Table 1). First, numbers of trees and shrubs are positively related until tree density exceeds 200 per acre, after which numbers of shrubs decreases. Secondly, production of herbaceous understory is inversely related to total woody overstory (trees and shrubs), a relation previously reported by Arnold and Schroeder (1955). Thirdly, more detailed analysis shows that trees and shrubs independently tend to suppress production of herbaceous understory.

PELLET GROUP RELATIONS

Numbers of accumulated pellet groups varied on areas sampled from 0 to 25 groups per 200 square feet. Pellet groups of both elk and deer could be segregated into zones of decreasing densities around areas of highest concentration (Figure 1). Moreover, there was a positive correlation between elk and deer pellets (correlation coefficient of 0.71).

Topographic effects: Among the four quadrants of the compass, northeastern exposures had 40 to 100 percent greater numbers of pellet groups than other exposures. Numbers of trees and associated shrubs were also highest on this exposure, and herbaceous understory was least here. For this particular habitat, shrubs appear to be more important than trees in influencing the deposition of pellet groups. Numbers of pellet groups were considerably higher where shrubs were associated with trees as compared to plots containing trees but no shrubs.

[3]Only trees over 6 feet tall were counted. Wavyleaf oaks less than 6 feet were counted as shrubs.

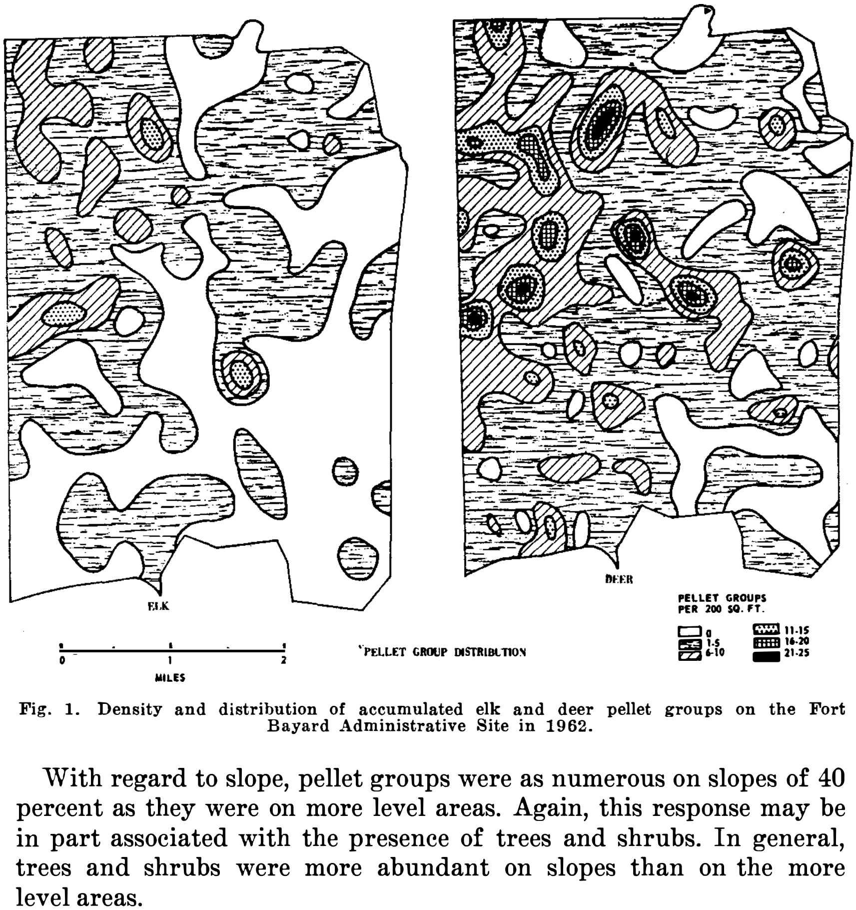

Fig. 1. Density and distribution of accumulated elk and deer pellet groups on the Fort Bayard Administrative Site in 1962.

With regard to slope, pellet groups were as numerous on slopes of 40 percent as they were on more level areas. Again, this response may be in part associated with the presence of trees and shrubs. In general, trees and shrubs were more abundant on slopes than on the more level areas.

Vegetation effects: The combined presence of trees and shrubs appeared to influence numbers of pellet groups of both elk and deer. At the lowest densities of trees and shrubs, numbers of pellet groups were lowest. Also, at highest tree densities, where shrub numbers decreased, pellet groups of deer and elk were not so high as where trees were of lesser and shrubs of greater density. Under these conditions, it appears that tree density can be either too low or too high for best habitat for elk and deer.

DISCUSSION

The above relations suggest that a livestock range improvement program of pinyon-juniper removal can be coordinated with habitat improvement for elk and deer.

Degree of slope is one factor that partially separates better range for livestock from habitat used by deer and elk. Cattle prefer to graze gentle topography (Glendening, 1944), while deer and elk apparently use slopes up to 40 percent as readily as level topography. On this area, a tree and shrub association (preferred habitat of elk and deer) is fairly abundant on slopes, whereas production of perennial grasses and forbs (preferred forage of cattle) is higher on more level sites where tree and shrub density is lower. At present, slopes steeper than about 15 percent are avoided when clearing pinyon-juniper because of the erosion hazard. This practice tends to improve the more gentle and better rangelands for cattle, and to preserve the steeper areas as habitat for elk and deer.

Exposure might be a consideration in coordinating livestock range and game habitat improvement programs in situations similar to the study area. Habitat use by elk and deer was highest on northeastern exposures where density of trees and shrubs was high and production of perennial grasses and forbs was low. Preservation of proper overstory and associated shrubs on northeastern exposures should help to maintain habitat conditions for elk and deer.

Concurrent with improvement of livestock range on more gentle slopes, development of elk and deer habitat might be possible on the steeper slopes and northeastern exposures. Present data suggest that trees can become too dense for the best production of shrubs. Where tree overstory exceeds about 150 trees per acre, removal or thinning of the overstory should improve shrub production. In this regard, McCulloch (1961) found annual growth of shrubs to be more than twice as great where pinyon-juniper overstory was eliminated.

Shrub density on local sites can become so great as to prevent access by deer and elk. Here, top removal and inducement of sprouting of such species as birchleaf mountainmahogany, Wright silktassel, and wavyleaf oak should improve accessibility and availability of shrubs for deer and elk.

Efforts to improve habitat conditions for deer and elk always raise the question of how much cover to retain to maintain overall habitat relations. Amount of desirable cover is not presently known for pinyon-juniper. In the chaparral of California, however, Dasmann and Taber (1958) suggest retaining two-thirds of the cover on north-facing slopes and one-third of the cover on south-facing slopes.

SUMMARY AND CONCLUSIONS

For the pinyon-juniper woodland on the Fort Bayard Administrative Site, tentative conclusions with regard to vegetation relations, habitat use by deer and elk, and land management implications may be summarized as follows:

Vegetation relations:

1. Shrubs increase with number of trees to a density of 151 to 200 trees per acre; in denser tree stands, number of shrubs decreases.
2. Production of herbaceous vegetation is inversely related to density of both trees and shrubs.

Habitat use:

1. Pellet groups of both elk and deer can be segregated into zones of decreasing densities around areas of highest concentration.
2. Northeastern exposures, with greater numbers of trees and shrubs and lesser amounts of herbaceous understory, have greatest concentrations of pellet groups.
3. Slopes up to 40 percent have as many pellet groups of elk and deer as more level areas.
4. Shrub abundance is the most important vegetation factor associated with pellet groups.

Land management implications:

1. Good coordination of livestock range improvement with game habitat preservation might be achieved by:
   a. Clearing only on slopes of less than 15 percent.
   b. Leaving existing cover on northeastern exposures.
2. On areas reserved for game habitat, conditions for elk and deer might be improved by:
   a. Removing or thinning trees, which overtop shrubs, where they exceed about 150 trees per acre.
   b. Cutting back sprouting species of shrubs that are so tall as to be inaccessible to elk and deer.

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DISCUSSION

DISCUSSION LEADER TOWNSEND: This reminds me of work that has been done and is now being continued in Montana relative to cattle, deer and elk relationships. They are finding there, to some extent, that the range condition has a direct bearing on the amount of competition or overlap of use and I would like to ask whether you have related your range conditions to that type of thing?

MR. REYNOLDS: We have no work at the present time relating use by either deer or elk to livestock range conditions. However, we are planning some of this work for the future because we have the same feeling as you have expressed—that there is a difference in competition for available range, depending upon the condition of the livestock range.

DR. WALTER P. TAYLOR (California): After a trip down into the part of the country that was mentioned, I got the idea that some of the long-range effects of brush control were not very well known or could not be anticipated at this stage of the game. I was very much interested in the paper in this regard.

Our whole study of brush control is too short-lived for me to gain anything from it. However, I wonder if you can anticipate the long-range effects with which, after all, our generation and those that come after us are going to have to deal.

One thing that I believe should be emphasized is the extreme value of the kind of work that has been reported. It is fine that this work is being done but there ought to be a lot more of it and it ought to be expanded and our conclusions ought to be rather cautiously drawn in view of the long-time effects.

The impression I got after going around South Texas was that we did not know for sure but what a lot of the brush control was going to lead to desiccation in the long run.

MR. REYNOLDS: I would just like to comment briefly on the statement just made and then go back to a statement that I remember was made a number of years ago. I think it is one that we might well adopt in our situation.

I think it was to the effect that in doing improvement work on habitat or range or forest management or anything else, it might be desirable to do as much as is necessary but as little as possible.

MR. JOHNSON (California National Cattleman's Association): I would like to congratulate the speaker on this paper.

To us in the cattle business, livestock means a great boon. Of course, we do not get around to meeting as often as we should and we probably are not acquainted with most of you. I am a hunter and I sure would like to congratulate all the speakers this morning for their fine reports.

MR. JULANDER (Utah): I would like to make a comment relative to competition. In previous studies we found that competition between cattle and deer could be as little as 10 per cent on ranges in good condition and not overutilized and up to 90 per cent or almost direct competition on overgrazed ranges which were overstocked.

AN INVESTIGATION OF WOODLAND CARIBOU IN NORTHWESTERN UNITED STATES

H. FRANK EVANS
North Idaho Junior College, Coeur d'Alene, Idaho

It was the purpose of this investigation to gather information on the past and present occurrence of caribou in northwestern United States, record alterations in habitat, evaluate population behavior through time, approximate present caribou status and perhaps make predictions as to the future of the species. The study was neither intensive nor experimental.

American woodland caribou, *Rangifer tarandus caribou* (Gmelin), still occurs in Rocky Mountain forests of northwestern United States and according to Banfield (1961) is indistinguishable from the caribou that formerly occurred in the Northeast and in the Lake States. The species is associated principally with climax coniferous forests and its main food item in winter is arboreal lichens (Edwards and Ritcey, 1960). In addition to being extremely nomadic it exhibits seasonal movements in mountainous country as described by Edwards and Ritcey (1959).

Data collection began in the fall of 1958 and continues but because of the size of the study area and other complex factors it can never be considered complete. Although the animals were observed on occasions, this study relied greatly on the observations of others as have other caribou investigations. The validity of such second-hand observations can be reasonably well established after interviewing the observers since caribou have such unique characteristics and behavior.

A very helpful technique was the use of a mosaic of plastic relief maps on the entire study area. This permitted the total complex of topography to be immediately comprehended. Then when caribou occurrences and habitat disturbances were plotted on the map, a better understanding was gained of possible animal movements, possible barriers and the comparative topography of the different areas of caribou occurrence.

To understand changes in caribou occurrence through time, it is important to understand the "roam range" concept which evolved from this study. This term implies that carbou will roam over an area large enough to contain an adequate supply of lichens to feed on and the adequacy of the supply will be subject to the age of the forest, the frequency and intensity of the caribou grazing and even the annual variations in snow depth which permits feeding at different heights. That the "roam range" will be extensive is implied by keeping in mind the very slow regrowth of lichens. This time-space "roam range" concept can be likened, though on a larger and longer scale, to the wanderings of other animals whose food supply is regrown seasonally. Reroaming of a particular forest locality may not occur for several caribou lifetimes.

Approximately thirty thousand square miles or an area the size of the State of Maine would be encompassed by a circumscription of all recent caribou sightings. This area is a bewildering array of mountain ranges of western Montana, northern Idaho and a small corner of northeastern Washington. It is dissected by the Kootenai River in its southern loop from British Columbia, the Flathead-Clark Fork-Pend Oreille River system and the lesser drainages of the Coeur d'Alene and St. Joe Rivers. Other than some state and private holdings, the principal forested areas are under the administrative jurisdiction of the Colville, Kaniksu, Kootenai, St. Joe, Lolo, and Flathead National Forests and Glacier National Park. Caribou may also have crossed the intervening Coeur d'Alene National Forest to have reached the St. Joe National Forest. A wide diversity of mountain terrain is included in this total area, with a corresponding diversity of possible habitat.

In winter caribou rely on the forest lichens and in summer they frequent the balds and alplands and high meadows for sedges, grasses and forbs (Edward and Ritcey, 1960) and they also have an affinity for lakes and swampy areas. The mountains throughout the study area provided these diverse segments of habitat in varying degrees. Before the advent of European man these ranges were forested with many timber types as dictated by the different moisture regimes, slope, soil, exposure and occurrence of fire. Not caribou habitat were the drier southern and western slopes and valleys exhibiting ponderosa pine, Douglas fir and associated species. On the other hand, the forest communities in moister situations consisted of larch, white pine, fir of two species, spruce, western red cedar and hemlock. In mature forests these trees exhibited a luxuriant growth of festooning arboreal lichens which are the acknowledged essential for caribou survival and caribou may be assumed to have experienced near optimum conditions.

Evaluating population behavior through time has been difficult. That caribou occurred more widely prior to 1900 can be established from several sources (Evans, 1960), but information concerning numbers is scant and the few records that mention appreciable numbers concern the Selkirk Mountains of the Kaniksu National Forest and the Yaak River country of the Kootenai National Forest. Previously existing habitat of mature forests of the moist valleys of the Coeur d'Alene, St. Joe and St. Mary Rivers and the adjacent moun-

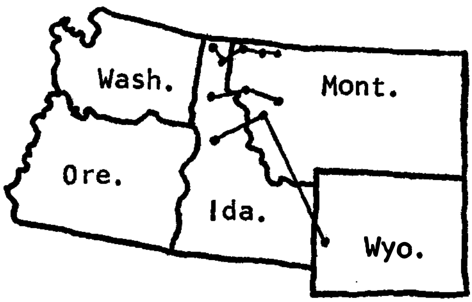

FIG. 1. Southern limits of caribou as based on reported occurrences. Lower line represents 1870's, upper line represents 1900 to 1950, and middle line represents 1950 to 1960.

tains in Idaho would indicate that caribou once occurred there in optimum numbers.

Figure 1 depicts the earliest specific references to caribou occurrence and these three references are also the southernmost sightings of recorded times. They were in the vicinity of Elk City, Idaho, in 1872 (Merriam, 1891), near Missoula, Montana, in 1860 (Cooper, 1868) and near Salt River, Wyoming, in 1877 (O. J. Murie, personal communication, 1959). All these records may represent caribou at or near the extremities of their roam range when greater populations existed in the Bitterroot Mountains of Idaho.

Caribou occurrences were plotted for the six successive decades since 1900. Figure 2 indicates nine lettered areas of occurrence. While there were a few sporadic occurrences in areas E and F, the upper four areas—A, B, C, and D—showed sightings in each successive decade. Therefore, it was assumed that there had been some continuous occupancy in all six areas. Area A of the Selkirk Mountains segment of the Kaniksu National Forest has been the area of greatest continued caribou activity. Fortunately, it was the one area in which a rather detailed analysis of habitat disturbance could be historically plotted.

In the sixth decade three caribou sightings revealed the animals in areas G, H, and I. Caribou had not been reported in the St. Joe River area (H of Figure 2) since before 1900. Thirteen caribou were seen near Hedley Peak near Thompson Falls, Montana, in 1959 (G of Figure 2) where no previous record can be established. Near the headwaters of the Blackfoot River in Montana (I of Figure 2), caribou were seen in 1960 but no evidence of previous occurrence in or near this area has been found.

During these same six decades, vast changes have occurred in habitat, primarily because of forest fires and logging as well as land draining and clearing for agriculture. Figure 3 depicts the major fires

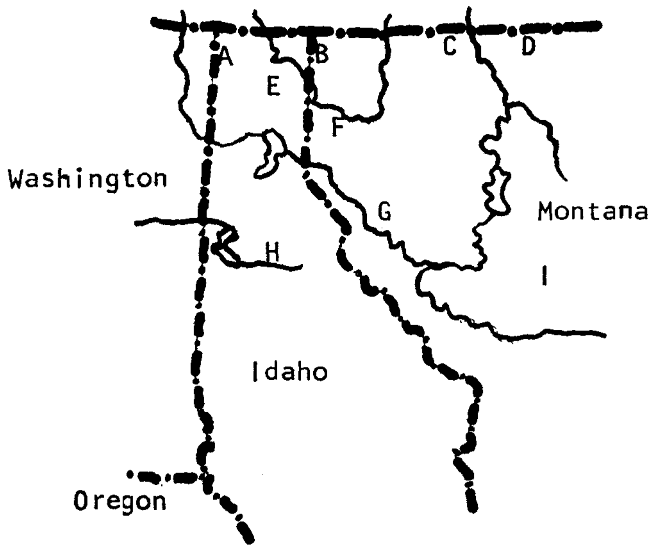

Fig. 2. Letters indicate areas of caribou occurrence.

Fig. 3. Solid areas indicate major fires in the study area that occurred between 1906 and 1953 (from U. S. Forest Service fire overlay maps). Shaded areas are unforested areas.

that occurred between 1906 and 1953 in the several national forests (as obtained from the records of the U. S. Forest Service) that were occupied by caribou near the beginning of the century. Fire has also been considerable in the contiguous forests of British Columbia and has been related to caribou declines by Edwards (1954).

Logging of the region's forests began in earnest in 1906 and has continued to date with earlier periods effecting a greater destruction at a faster rate. Logging of swampy lowlands was followed by land drainage for agriculture and permanent reduction of one of the seemingly favored elements of caribou habitat. Many thousands of miles of logging roads and forest administrative roads now penetrate virtually all of the mountain areas. However, the eastern spur of the Selkirk Mountains has not yet been completely traversed by a road and this remains the area of greatest caribou concentration. While logging continues and results in the annual diminution of mature forests, it is now considered to be on a sustained yield basis. The harvest of spruce timber in caribou highland habitat followed the severe timber blowdowns of 1949 which brought the threat of bark beetle epidemics (Anon., 1953). It was the beetle control work and spruce logging that brought man again into more frequent contact with caribou. Previously the animals had been less frequently seen by occasional forest workers and few were aware of their presence.

While no record exists of the extent of timber harvest throughout the entire study area, the logging pattern on the Selkirk segment of the Kaniksu National Forest was plotted by decade with the aid of a forest administrator long associated with the area (Evans, 1960). The total amount of burned and logged forest in this segment was then subtracted from the total and it revealed that about 25 per cent of the area remained comparatively undisturbed. However, much of the remaining amount was rocky habitat of mountain goats—and other was not suited for caribou occupancy. The diminution of caribou habitat had been enormous, but there remained a sprawling 590 square miles of unburned and unlogged area, 80 percent, or approximately 470 square miles, of which might be considered reasonably good caribou habitat. Using the carrying capacity assigned by Cringan (1957) to old-age forest, it was computed that the carrying capacity was 94 animals. There are too many variable factors involved to compute a more detailed caribou range analysis. The approximate population figure of 100 animals for the Selkirk area does not seem an unreasonable one, but more may be present. The mobility of the species might lead to considerable deception in any more arbitrary computation of the probable population.

In addition to forest fires and logging, other forces have decreased the habitats suitable to caribou. The principal valleys now support field crops and domestic live stock grazing and the continually growing population of the towns of the area are supported by a forest and agricultural economy.

The depletion of the Kaniksu Forest by logging is considered to be typical of what occurred throughout the several forests of the study area. The fire loss in the Kaniksu is probably less severe than the loss to fire in the other forests. Lacking more qualitative means of measuring the extent of caribou habitat due to the variability of the forests and the topography, lack of detailed forest resource figures and the sheer logistics of so vast an area, it is the subjective impression of the investigator that the Selkirk Mountains of the Kaniksu National Forest presently contain the principal caribou habitat in the Rocky Mountain forests of the United States.

While there has been a general decline in caribou population as well as a severe diminution of caribou range, records of past occurrences are so incomplete that no rate of decline can be correlated with particular habitat disturbances or human activities. Habitat disturbance was not one of gradual attrition but often of a sudden and explosive nature, and population declines probably behaved in a somewhat similar manner. While caribou still occurred in some areas, their final disappearance in such areas was probably effected by illegal hunting—often by miners, trappers, and sheepherders (extensive sheepherding followed major fires). Mining and prospecting has been associated with caribou habitat since the 1860's though such activity has abated in some areas. These pursuits did little or no direct damage to habitat, but where men and caribou occurred together, there must have been illegal hunting. Before the advent of European man it is presumed that Indians likewise caused a constant attrition of caribou numbers, for early white visitors to the area have left records indicating that big game was scarce—a fact consistent with our present knowledge that other members of the deer family are associated with the relatively early stages of forest succession. Several sources (Evans, 1960) establish the fact that Indians did indeed take caribou, but they do not indicate a particularly prominent part in the Indian culture of the area. Nevertheless, since the habits of the caribou render it so vulnerable to overexploitation (Cringan, 1957), even the early Indians with crude weapons could have over-hunted the species.

A Canadian trapper of the Boundary District of the Selkirk Mountains has seen caribou annually during his winter activities for forty years and he reports that the population has appeared to be relatively stable. The animals in that area now frequently feed on the lichens on the slash of the trees felled by logging. The availability of this food probably curtails their normal wanderings during the fall and winter season when logging operations are active. The sudden local abundance or availability of food would seem to have no long-term effect on population, but the logging will lead to further diminution of range. Since caribou are attracted to the relatively old-aged forests and since logging of such timber stands will continue, caribou will probably continue to maintain contact with logging operations. The danger manifested in such an association of men and game animals is sure-apparent. In such remote areas, poaching is inevitable and no reasonable measures can control it.

The future of caribou presents several enigmas. If serious fires are averted, if future intensive forestry practices do not too dramatically alter optimum lichen growing conditions and if illegal hunting does not lead to its extinction in the region, are caribou likely to survive in any numbers? The answer to the question poses another—will the seral forests following logging and fire mature enough to support sufficient lichen pastures to sustain the species before these forests are likewise assigned to logging? Future logging practices will probably demand less timber size. Only time, caribou population behavior and lichen ecology studies may reveal the answers.

This creature which is associated with climax or relatively mature forests would appear to be doomed since man does not maintain climaxes but destroys them. However, caribou possess one remarkable characteristic that assists them in their seemingly tenuous existence. Their extremely restless, roaming behavior (Murie, 1935) seems to persistently probe enormous geographic areas and thus bring the species in contact with such habitat that has matured sufficiently to support them. If such supporting habitat which has been destroyed early in the century is regenerated before the species is reduced too severely in numbers, caribou may find it and yet survive in the forests of northwestern United States.

Physical barriers within the study area were considered almost nonexistent since it was established that caribou appear to travel high ridges in the summer season. Therfore these ridges provide excellent avenues of travel by means of which the animals may traverse large segments of unsuitable habitat and find islands of aging forest where winter lichen pastures will feed them until summer makes grasses and forbs again available in the highlands. Fortunately, man is not often found in the summering areas above timber and does rather little hunting in dense forest, so caribou habits may permit some respite from human contact. On the other hand, the restless, extensive wandering increases the likelihood of contact with humans.

The roam range concept permits an understanding of several phenomena associated with caribou. First, it permits an explanation of the variation of year to year distribution and seeming fluctuation in populations that might be observed. Second, it adequately explains the reoccurrence of caribou in areas widely separated in time and space from previous reports of the animals as well as accounting for their appearance where they have not been previously reported. Third, it permits an explanation of how the Kaniksu Forest herd may have remained relatively stable when there was no evidence of predation or disease but presumed normal reproductory behavior. If small bands wander from the area it subtracts any increment of increase and accounts for reappearance elsewhere. Fourth, it would tend to prevent a "boom and bust" of populations which would deplete their range. It was the reoccurrence of caribou in the sixth decade in the three widely separated areas that was the most encouraging aspect of this study and the one which permits some hope for this rare species in northwestern United States.

The prediction is made that caribou will continue to wander widely in their small bands of a few to a dozen or more animals and will occasionally be reported. If the west side forests of Glacier National Park reach sufficient maturity and are not reburned, a stable population of caribou may become establshed there. It is further predicted that man will continue to erode caribou numbers as the wandering animals intersect human activities. This study revealed thirteen illegal caribou kills in a nineteen year period (Evans, 1906) and the probability of discovering illegal kills will be conceded as being very small indeed.

Since ever-increasing human populations rely ever more heavily on diminishing old-age timber stands in the economy of the region, it does not appear feasible that any assistance can be given to the management of caribou habitat to assure higher population levels. The wandering nature of the animal has been of a high survival value to the species because of slow lichen growth. This characteristic now enhances its chance for survival since forest succession is an even more time-consuming process.

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DISCUSSION

DR. PAUL DALKE (Idaho Cooperative Wildlife Research Unit): Do you have information on the range of these caribou over international boundaries?

MR. EVANS: Yes, there has been a tremendous amount of forest destruction by fire in the Canadian forests. However, as a general rule, these animals do not respect political boundaries. They follow tracks across the boundaries very frequently. They range quite a bit farther north but, at any rate, there has been quite a great deal of habitat destruction up there.

MR. CULLEN (Idaho Fish and Game Commission): I think that this was a very well presented paper and I would just like to say that I know a little bit about this man's background and know that he spent hours and hours and traveled hundreds and hundreds of miles in gathering research for this presentation.

I think that I should also comment as to the desirability of having this woodland caribou in the northwestern states and I will say, as far as Idaho is concerned, I think it is a very desirable species. However, we certainly have dim prospects for the development of any major herds in our area. Mr. Evans, I believe, has fully covered the reasons why. One of the reasons against this is this factor of new roads being opened up. Another is this matter of poaching, due to the fact that they do have accessibility to the herds at this time, which likewise would be a factor relative to the growth of the herd. Also, there is the factor of the limited range. We, in our case, also have some competition from moose.

We are in the process of making a survey on a big game count at this time, attempting to find a band of caribou we had last year and which we have not been able to locate this spring.

Therefore, I think that for the various reasons that Mr. Evans has explained, the prospect of raising these animals would indeed be dim in the State of Idaho.

CHAIRMAN MILLER: Thank you very much for your comments. Of course, there is great satisfaction in knowing that the woodland caribou will be with us even though population levels may remain low.

RELATIONS BETWEEN HUNTER ACCESS AND DEER KILL IN NORTH CAROLINA

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Big-game hunting provides outdoor recreation for over 6 million hunters in the United States each year. They come from all walks of life, from big cities, from rural areas. They spend a great amount of money (approximately ⅓ billion dollars in 1960) and time (almost 40,000,000 days) in pursuit of their sport. Furthermore, it is predicted that the number of days spent hunting big game will almost double by the year 2000[1].

There are two important problems in managing deer herds for this ever-increasing number of big-game hunters. One involves manipulation of forest-game habitat (clearings, forest improvement, harvest cuttings, planting, seeding, fertilizing, and development of water holes) in an effort to increase game populations. The second involves minimizing browsing damage to valuable timber and range resources by using legal hunting to remove surplus animals. Harvesting surplus animals is generally sought by regulating seasons, bag limits, and the number and distribution of hunters. In some areas, however, the optimum balance between deer populations and forage supplies is not maintained because of inadequate distribution of kill throughout a range.

Knowledge about hunters' habits, particularly their use of forest roads and trails, has important management implications for improving deer harvest and recreation potential. It is generally assumed that access is an important tool for producing uniform deer kill by better distribution of hunting pressure. The questions are how much, where, and what kind of access should be used.

Little information is available concerning distances deer hunters move from roads or trails in quest of game. Severinghaus[2] reported that although some hunters in New York State killed bucks more than 7 miles from the nearest road, a large percentage of deer were killed by hunters relatively close to roads or hunting camps. Stenlund, *et al.*, (1952) report that 90 per cent of all deer harvested

[1]ORRRC Study Report 26. 1962. Prospective Demand for Outdoor Recreation. 61 pp.
[2]Severinghaus, C. W., 1952. Determination of the location of hunting pressure and ratio of success of central Adirondack deer hunters in relation to distance hunted from a road. State of New York, P-R Project W-89-R-1, Big Game Management Investigations, Job VII-A.

in 1942 on the Gogoka Management Area, Superior National Forest, were killed ¾ mile or less from a road or trail, and that only a few hunters ventured more than ½ mile from the nearest access. A study made in Allegheny County, Virginia, by Giles and Gwynn (1962) revealed that hunters carried their deer about 0.6 mile to a vehicle, and the average distance walked on the day they shot the deer was 4.1 miles. Johnson (1943) states that studies of hunter distribution over the game range made on the national forests of the Southwestern Forest Region showed a high percentage of game killed within 1 mile of an automobile road, and where topography or policy limited road construction, deer hunting was quite limited.

In order to gather information on the use of roads and trails by successful deer hunters, a cooperative study was started by the North Carolina Wildlife Resources Commission, the U. S. Fish and Wildlife Service, and U. S. Forest Service. Commission personnel plotted deer-kill locations on 13 wildlife management areas in western North Carolina[3] (a mountainous region of steep and rugged topography) during four hunting seasons, 1959 to 1962, and on the Uwharrie Wildlife Management Area (an area of gently rolling hills and broad valleys) during 1960 to 1962. All successful hunters were assisted in plotting deer-kill locations on small-scale compartment maps. A total of 502 locations was obtained from the Uwharrie, and 3,633 from western North Carolina.

This study was established on several basic assumptions:

1. Kill location represented hunter distribution in relation to access. Although kill location also reflected deer distribution, it was felt this effect was negligible and that deer distribution was largely random, if not rather uniform.

2. Hunters killed deer where they found them and were not influenced by distance of drag. Some hunters occasionally claim to pass up deer because of the distance factor, but the authors doubt if this is a major consideration.

3. Road and trail locations are independent of deer distribution because they are built through poor as well as good deer range.

4. Although plotted locations of deer kills were inexact because of hunter inability to pinpoint accurately the location of kill, it was assumed that this inaccuracy was not biased. In fact, accuracy was very likely high because most hunters were furnished a small-scale map of the compartment to aid in recognizing principal relief features of the area hunted. It is believed that most deer-kill locations were probably plotted within 300 feet of actual location.

[3]Western North Carolina Wildlife Management Areas include Daniel Boone, Fires Creek, Flat Top, Harmon Den, Mt. Mitchell, Pisgah, Rich Laurel, Santeetlah, Sherwood, South Mountain, Standing Indian, Thurmond Chatam, and Wayah.

The distance between each plotted deer kill and nearest road or trail was determined with dividing calipers. The following characteristics of each kill location were recognized separately for bow, buck, antlerless, and either sex hunts, as well as all hunts combined:

1. Distance to nearest road or trail.
2. Distance to trail, if closer than road.
3. Distance to road, if closer than trail.
4. Distance to road over trail, if trail at point of kill is closer than nearest road.

These attributes of 4,132 kills, plus identification data, were punched on IBM cards, sorted, and tabulated. Because these data represent all information available (not a sample) no statistical treatment was necessary.

RESULTS

Relationship Between Harvest and Nearest Access

Mileage and location of roads and trails were generally so favorable that it was not possible for hunters to travel long distances cross country without encountering some type of access. Approximately 40 per cent of all areas checked, in both the Piedmont and mountains, was within 300 feet, 63 per cent within 600 feet, and 98 per cent within 2,400 feet of the nearest road or trail.

Hunters, however, apparently stayed closer to access on the Uwharrie Wildlife Management Area than on the western, mountainous areas. Forty per cent of total kill on the Uwharrie, all hunts combined, was made within 300 feet of the nearest road or trail, a zone containing 42 per cent of the area. Eighty-one percent of kill occurred within 600 feet of access, a zone containing 64 per cent of the area. Hunting pressure diminished rapidly beyond 600 feet, with only 19 per cent of the harvest scattered over the remaining 36 per cent of the area. No deer were killed farther than 1,800 feet from a road or trail (Table 1).

TABLE 1. RELATIONSHIP BETWEEN AREA ACCESSIBILITY AND LOCATION OF DEER KILL, ALL HUNTS COMBINED, UWHARRIE WILDLIFE MANAGEMENT AREA, 1960-1962, INCLUSIVE.

Distance from road or trail	Area lying within designated distance of nearest access		Deer killed within designated distance of nearest access	
Feet	Per cent	Cumulative per cent	Per cent	Cumulative per cent
0-300	42.0	42.0	40.2	40.2
301-600	22.0	64.0	40.6	80.8
601-1,200	23.0	87.0	18.0	98.8
1,201-1,800	9.5	96.5	1.2	100.0
1,801-2,400	2.5	99.0	0	0
Over 2,400	1.0	100.0	0	0

TABLE 2.—RELATIONSHIP BETWEEN AREA ACCESSIBILITY AND LOCATION OF DEER KILL, ALL HUNTS COMBINED, WESTERN NORTH CAROLINA WILDLIFE MANAGEMENT AREAS, 1959-1962, INCLUSIVE.

Distance from road or trail	Area lying within designated distance of nearest access		Deer killed within designated distance of nearest access	
Feet	Per cent	Cumulative per cent	Per cent	Cumulative per cent
0–300	38.0	38.0	25.1	25.1
301–600	24.0	62.0	28.7	53.8
601–1,200	22.0	84.0	29.6	83.4
1,201–1,800	9.0	93.0	10.0	93.4
1,801–2,400	4.5	97.5	4.3	97.7
Over 2,400	2.5	100.0	2.3	100.0

In contrast to the Uwharrie, successful hunters on the western North Carolina Wildlife Areas apparently spent more time on "off-trail" zones. They harvested only 25 per cent of their kill, all hunts combined, within 300 feet of the nearest access, a zone containing 38 per cent of the area; 54 per cent within 600 feet, a zone containing 62 per cent of the area. At the same time, the zone from 601 to 1,200 feet contained only 22 per cent of the area, but accounted for 30 per cent of the kills; the 1,201- to 2,400-foot zone contained 14 per cent of the area and accounted for 14 per cent of the total harvest. Also, a few deer in the mountains were killed more than 2,400 feet from the nearest road or trail (Table 2).

Type of Hunt and Kill Location

The relationship between access and kill by type of hunt (bow, buck, antlerless, and either sex) was highly uniform on the Uwharrie. Per cent of total harvest occurring within 300 feet of access ranged from a low of 31 for buck hunts to a high of 47 for antlerless hunts; within 600 feet of access, from 77 for buck hunts to 88 for antlerless hunts. Mean distance from deer kill to nearest access for all type hunts was between 400 and 500 feet.

On the other hand, type of hunt apparently was related to distance from nearest access on the mountain game management areas. Archers, with 78 per cent of their kills within 600 feet of the nearest road or trail, apparently traveled the least cross-country distance. Antlerless, either sex, and buck-season hunters killed 62, 53, and 53 per cent of their deer within 600 feet of the nearest access. The average kill occurred between 500 and 600 feet from access during archery hunts, 600 and 700 feet during antlerless hunts, and 700 and 800 feet during buck and either sex hunts. Mean distance from kill to nearest access for all type hunts was approximately 750 feet.

Relationship Between Harvest and Road vs. Trail Access

All plotted locations were examined by Station researchers to determine whether kill was made closer to road or to trail. It was found on all wildlife management areas that apparently equal use was made of trails and roads. On the Uwharrie Wildlife Management Area, approximately 70 per cent of total access consists of trails (48.5 miles) and 30 per cent of roads (20.1 miles). Number of deer killed was in direct proportion to this ratio between roads and trails. Of 502 deer harvested, 70 per cent were killed nearer trails, and 30 per cent nearer roads. Where kills were made closer to trails, all hunts combined, 42 per cent were within 300 feet, 83 per cent within 600 feet, and 99 per cent within 1,200 feet of trail. Where kills were made closer to roads, 36 per cent was within 300 feet, 76 per cent within 600 feet, and 100 per cent within 1,200 feet of road (Figure 1).

Hunters also made about equal use of roads and trails on the western North Carolina Wildlife Management Areas. The ratio of trails and

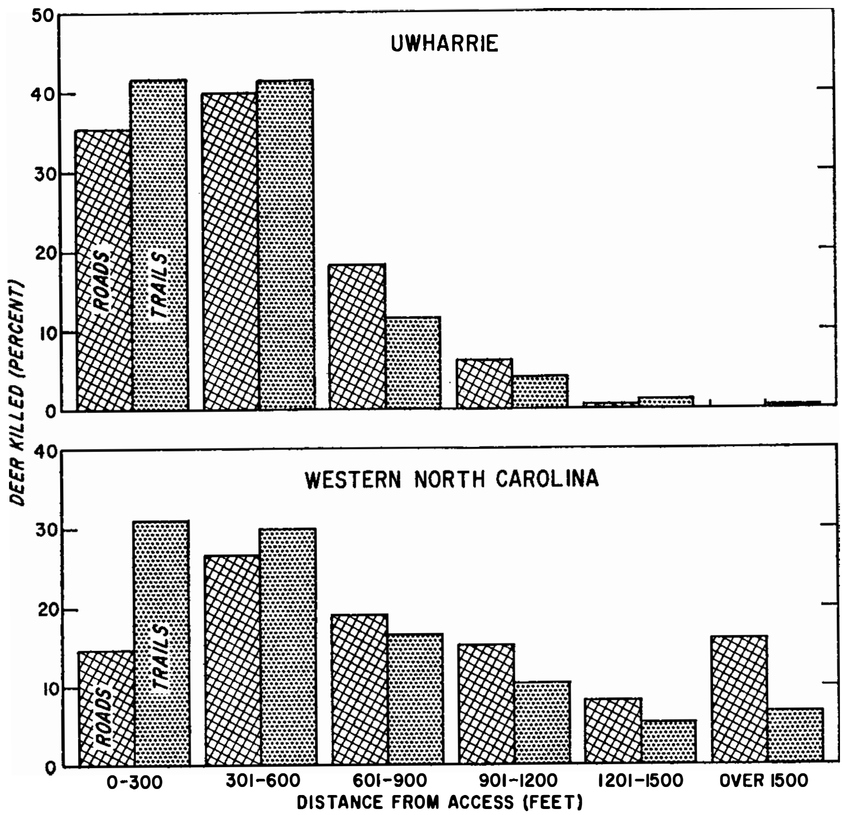

Fig. 1. Distribution of deer kill in relation to distance from roads vs. trails on wildlife management areas.

roads in the mountain areas[4] was similar to the Uwharrie with approximately 60 per cent trails and 40 per cent roads. A total of 2,263 kills (62 per cent of the total) were made where trails were closer than roads, contrasted to 1,370 kills nearer roads than trails. Where kills were made closer to trails (all hunts combined), 31 per cent were within 300 feet, 61 per cent within 600 feet, and 88 per cent within 1,200 feet of a trail. Where kills were made closer to roads, 15 per cent were within 300 feet, 42 per cent within 600 feet, and 76 per cent within 1,200 feet of a road (Figure 1).

Relationship Between Kill Location and Distance to Road Over Trail

It was assumed that most hunters returned to a road with their kill along a nearby trail, rather than cross country, even though cross-country distance was sometimes shorter than trail distance. We believe that exceptions to this assumption are generally uncommon. Accordingly, distance from each plotted kill to the nearest trail (if closer than a road) and thence along the trail to a road was determined.

On the Uwharrie Management Area, average drag distance to roads along trails was quite similar for each type of hunt: 2,500 feet during antlerless hunts, 2,200 feet during buck hunts, 2,100 feet during bow hunts, and 2,000 feet during either sex hunts. For all hunts combined it was 2,100 feet. Only one deer was killed over 1 mile along a trail to a road.

On the other hand, hunters moved their kills longer distances along trails on the western North Carolina Management Areas than on the Uwharrie. For all hunts combined, hunters dragged their deer an average trail distance of 4,300 feet. Almost 25 per cent of total kill occurred at trail distances greater than 1 mile, and 4 per cent at trail distances greater than 2 miles from a road. Distances over trails averaged 4,600 feet during buck hunts, 3,800 feet during either sex hunts, 3,600 feet during antlerless hunts, and 2,700 feet during bow hunts.

DISCUSSION

An aerial view of the Uwharrie and the western North Carolina Wildlife Management Areas reveals systems of well-spaced roads and trails crisscrossing the landscape. Most viewers of this scene would probably feel that almost any portion of the forest is easily accessible to the hunter. And, indeed, it apparently is accessible. Approximately 40 per cent of each Wildlife Management Area was within 300 feet of some road or trail, and 63 per cent was within 600 feet. Less than 2 per cent of the total forest was beyond ½ mile from either

[4]Detailed measurements were made on five of the western North Carolina Areas to determine miles of trails and roads. A total of 223 miles of trails and 156 miles of roads was measured on the five areas, a ratio of 6 to 4. It is assumed that this approximate relationship existed on all mountain areas.

road or trail. If close placement of roads and trails is the answer to obtaining a uniform distribution of kill throughout a range, these are game management areas where this can be accomplished.

In the mountains of western North Carolina successful hunters made exceptionally good use of all portions of the forest, and kills apparently were uniformly distributed. Hunters in the Uwharrie Management Area, on the other hand, apparently stayed much closer to access and did not generally penetrate remote sections (Figure 2).

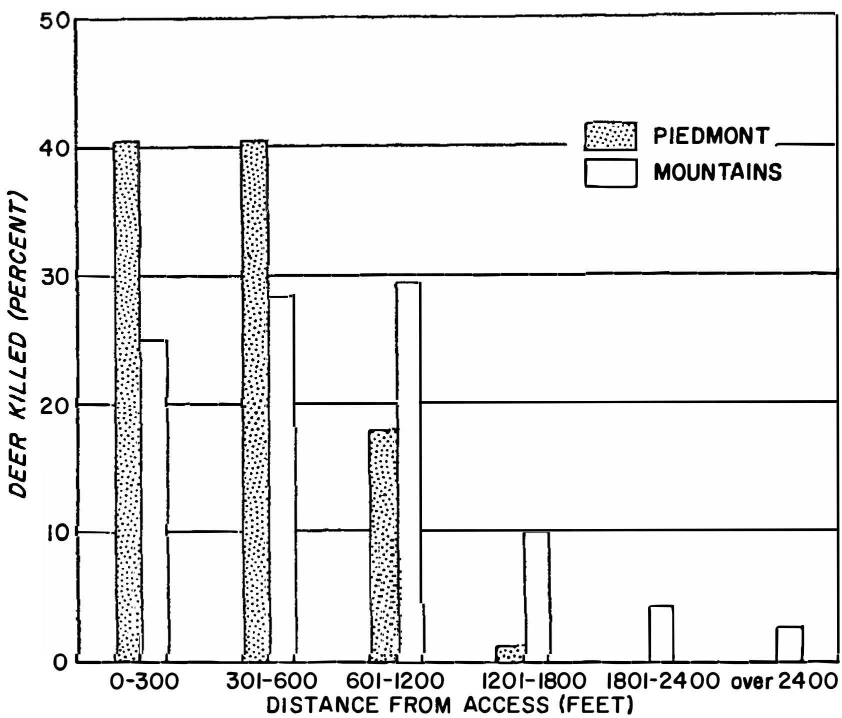

Fig. 2. Hunters killed deer closer to access on the Piedmont (Uwharrie) than on the mountain areas.

We can only speculate about the reason for this very different use of access between areas. For one thing, the Uwharrie and the western North Carolina Management Areas are quite dissimilar in topography and proximity to population centers. The Uwharrie, for example, is located in an area of gently rolling hills and broad valleys. It is virtually ringed by the urban industrial center of the State. The western

North Carolina Management Areas, on the other hand, are located in a steep and rugged mountainous region. These areas are largely populated with rural residents living in small, rather widely-scattered communities or small farms. According to local game managers, the Uwharrie is heavily used by hunters from nearby cities, whereas many hunters on the western areas are rural residents who spend much of their lives in the out-of-doors.

Could differences in hunting habits between urban and rural hunters account for the different use of access between Piedmont and mountain areas? If so, efforts to obtain uniform distribution of hunting effort and kill might entail more than simply close placement of roads and trails. Plans for access development should possibly include study of such things as visibility, terrain, and type of hunter using the area.

Whatever the reason, or reasons, for the regional differences, our results indicate that the access system on the Uwharrie may not be adequate for the most effective kill distribution and that additional roads, or especially trails, may be desirable. In the western areas, however, with a much more uniform kill distribution, we suspect that present access is entirely adequate.

Perhaps the most important finding drawn from the study was that roads and trails apparently served about equally in distributing successful hunting pressure. Obviously, trails received quite heavy use in dispersing hunters away from roads. In addition, the fact that hunters moved their kills an average trail distance of approximately 2,100 feet to nearest road on the Uwharrie, and 4,300 feet on the western management areas indicates the value of this type of access. This finding may be of considerable import to forest and game managers; trails can be built into areas much more easily than roads where greater deer harvest is desired. Good trails, though certainly not inexpensive, are much less costly to build and maintain than roads, and frequently they are much more desirable aesthetically.

Questions concerning how much, where, and what kind of forest access should be used to obtain desired distribution of hunting pressure have not been answered by this study. But considerable light has been shed on some basic and important relations between deer hunting and use of roads and trails. Furthermore, these findings will serve importantly in planning new work to find ways of providing full recreation benefits from fish and game resources to meet the sharply increasing demand for outdoor recreation.

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DISCUSSION

DISCUSSION LEADER TOWNSEND: That was certainly a very excellent presentation. I believe we are all interested in the material developed here, particularly those of us who have been faced with the problem of attempting to get the hunter and the deer together. This, of course, is also the problem of hunter access to areas of deer overpopulation.

MR. JOHN WILEY (Missouri Conservation Commission): I was particularly interested in your paper because I feel personally we need more research on the hunter himself, as well as the hunted.

I have two questions. As I understand it, your information was collected from the successful hunter. Did you study the unsuccessful hunter? It seems like total distribution of hunters here plays an important role?

MR. JAMES: No, John, we did not. This study is based entirely on the successful hunters. However, three cooperating agencies presently have a study plan for review. We are going to interview the hunter as he leaves the game management area and administer a questionnaire. We are going to ask him to plot the distance he traveled during his day's hunting activities, plot the location of the kill, if successful, and also ask him a number of questions related to the socio-economic phase of it. We will find out where the hunter is from, what his occupation is, his educational levels, etc.

MR. WILEY: I think you have answered my second question. I just wondered if you had in mind hunter characteristics studies and if these were evaluated in conjunction with access?

MR. JAMES: We realize the first study has weaknesses and we think we can tie it all together if we do get the other information.

MR. HODGSON (Minnesota Fish and Game Department): We did a small study somewhat similar to yours that obtained very much the same results. Over 90 per cent of the hunters that were successful, killed their deer within a half a mile of the road. I am wondering if you feel that maybe the weight of the animal might have some bearing on the situation. I know in our state we seldom have a hunter carry a deer. Do you have anything on average weight?

MR. FRANK BARICK (North Carolina Wildlife Resources Commission): I would like to say that our North Carolina deer range in weight, gross weight, somewhere around 100 to 125 pounds and sometimes as low as 85 pounds. These, of course, are the smallest. The larger ones, in Western Carolina, will get up as high as about 175 and occasionally 200 pounds. Some of the Eastern Carolina deer, those particularly around agricultural sections, will top 200 pounds and go as high as 225 pounds.

We do have quite a few of the hunters in the western part of the state carrying their deer out and, of course, we discourage this—we encourage them to drag them out because of the safety factor. Also, there are some mechanical devices being considered at the present time. This is a question we are considering right now.

Since the advent of the "tote goat" during the last year or two, we have had a few inquiries as to the possibility of using this as a means of getting farther back into the woods. We have heard from the administrators of the forests, the district rangers, and some of them say that this will be fine. Others, of course, have the opinion that the use of the tote goat on wood trails would create serious erosion hazards. Also the hunters themselves, as well as some of those who manage the hunts, are divided in their opinions as to the safety of this two-wheeled tote goat. It is a motorcycle sort of thing. I am sure most of you are familiar with it. Therefore, as to whether or not we will allow the use of this conveyance is a question which still has to be decided.

Also, the use of other four-wheeled vehicles is of varying degree on the Uwharrie. Many of the trails there have been built with bulldozers, which was possible because of the relatively less precipitous terrain. Therefore, we do have quite a few jeeps going along those woodland trails.

I might also say that we started out several years ago to develop a system of trails sufficiently intense that no person of any management area would be more than one-quarter of a mile from a trail or road. On our western area we have not as yet attained this goal, but even so, we appear to have obtained a very uniform distribution of kill.

Also, in the more urban portion of the state, we have a much more intensive system of roads and trails than in the western part of the state and even this does not appear to be quite adequate as far as the more urban type of hunters are concerned. Our data indicates that we perhaps ought to have more trails here.

DISCUSSION LEADER TOWNSEND: Thank you very much. I regret that our time is running a bit short and so we will have to cut our discussion and I will now turn the meeting back to the Chairman.

CHAIRMAN MILLER: This winds up the forest-range program. I want to again thank our speakers for a job well done. Many of the subjects have been briefed to get within the time limit; they will certainly bear further reading and study in the "Proceedings."

I want to particularly thank Joe Townsend for pinch-hitting for Fletcher Newby. He has done a fine job on short notice.

TECHNICAL SESSION

Wednesday Morning—March 11

Chairman: DWIGHT F. RETTIE
Assistant to the Commissioner for Public Affairs, U. S. Fish and Wildlife Service, Washington, D. C.

Discussion Leader: JAMES F. KEEFE
Chief of Information, Missouri State Conservation Commission, Jefferson City, Missouri

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CONSERVATION EDUCATION AND INFORMATION

CAN FIVE MILLION READERS BE WRONG?

WILLARD T. JOHNS
National Wildlife Federation, Washington, D. C.

Let's assume that we, as communications specialists in federal, state or private conservation organizations, have a potential listening audience of some 25 million Americans—men or women who purchase a hunting or fishing license and therefore have a special vested interest in how we manage their great outdoors, plus the wildlife resource upon which much of their pleasure is based.

Let's futher assume we regularly speak to at least one-fifth of this audience—five million persons. These are the average, intelligent and literate sportsmen who subscribe to our magazines, watch our television programs, read our press releases in their local newspapers, hear our radio programs, and come to see and hear our department speechmakers.

Finally, let's give ourselves—and our departments—credit for knowing what we are talking about in resource management—in telling conservation's truth, the whole truth and nothing but the truth.

If these assumptions are valid (and I think you will agree that they are at least a conservative estimate of the "enemy" situation), then why is there so much misunderstanding? Why do people so often ignore our recommendations, fail to follow our sound advice, or accuse us of being wrong about wildlife management? Why is adverse public opinion on so many key issues so much of a headache to our administrators? Isn't anybody out there listening?

Perhaps I can illustrate this point with a simple little story. I'm going to describe a particular situation—and ask you a simple question.

You are a conservation department employee flying in a new jet airplane between Chicago and Las Vegas. On board the plane are a number of businessmen, each with different reasons for being there and each with different points as their ultimate destination.

The interior of the plane is decorated in light blue, has a dark blue aisle carpet, and utilizes indirect lighting. The two stewardesses are also dressed in blue and wear pert little hats.

There are five specific passengers who deserve mention. One, a retired Navy captain, is headed for Los Angeles. He is 60 years of age. The second is a public relations counselor, age 50, who is afraid of flying and sits near the aisle. The third is 40 years old, a successful hotel manager who is flying to Reno. The other two people we would like to mention are both insurance men. One is 45 years old and the other is 30. Both work in Lincoln, Nebraska.

How old is the conservation department employee?

If you don't know the correct answer, you weren't listening.

And that is truly our most perplexing conservation education problem—in every organization, in every state. People simply are not listening to us. Until we can get them to listen, we can't begin to get them to understand. Until they understand, they will never act. And unless they act, we have wasted all our time, talent and money.

Why don't people listen? Well, have you ever stopped to count the voices we hear each day? Have you ever considered the number of words, either written or spoken, which are aimed directly at us—asking us to buy something, to do something, to vote, to decide, to think, to move, to use, to avoid, to conserve?

Each day in America the average citizen is the target of over 1,600 commercial advertising messages. Each week in America the average farm family receives through the mails more than four times the amount of reading material than they possibly have time to read.

Truly we live in an age of communication—a century in which the competition for a man's mind has exploded almost beyond belief. We all are aware of the population explosion, the technological explosion—but few of us are as yet fully aware of the explosion in human knowledge, coupled with the means of transmitting that knowledge from one mind to another.

The result has been a tremendous amount of noise on the communication lines, leading to an intriguing paradox. It seems that as the human mind is constantly being bombarded with more and more information, so is that mind becoming less and less capable of absorbing, understanding and retaining that information.

Countless examples prove this theory but one classic illustration comes to mind. Shortly after this nation, through a most tragic event, installed a new president, the Trenton, New Jersey, *Evening Times* sent a reporter out to see if the man on the street could recognize two men in a news picture—French President Charles deGaulle and President Lyndon B. Johnson of the United States. The reporter checked 30 people. Here are the results:

11 people recognized both men and identified them by name.
4 others recognized both men but couldn't think of Johnson's name
7 knew Johnson but not deGaulle (4 of these persons identified deGaulle as Nikita Khrushchev)
8 other people recognized neither man

So you see, perhaps that old Chinese proverb about a picture being worth 10,000 words may not be so true after all. In this case, the reporter was sent out because of just two words ("right" and "left")—the two simple words the photoeditor felt were hardly necessary in identifying two world-famous men.

Why don't people look, or listen, or remember? For the answers we must turn to the psychologists, social scientists, and motivation researchers. They don't as yet claim to have the full, final answers on human behavior—but in recent years they have made tremendous progress. Unfortunately, very few of us, I'm afraid, have taken the time to study the results achieved so far. It's high time that we did.

Psychologists, for example, show us that humans have an inability to sustain attention over a long period of time. In fact, their research shows that our attention span rarely exceeds a few seconds. It is sort of an "on and off again" process in which we hear the message for a moment, turn it off for a moment, and then return to what is being said. Who among you, for example, has not been counting the lights in this room while I've been speaking, or day-dreamed about where you will be on the opening of trout season this spring, or thought of many other things than the one about which I've been talking?

There is still another reason for not listening. The average speaker talks at a rate of about 125 words per minute—but the average listener "thinks" at a rate of between 300 and 500 words per minute. This allows a "listener" plenty of time for mental activity other than listening. So even though you may be an accomplished orator and have a very important message to deliver from the platform or from a radio-TV studio, not all of your message may be heard.

Even when you are heard, you probably will not long be remembered. Several years ago the University of Minnesota tested the listening ability of college students and businessmen who attended adult education courses, The result show that the average person remembers only about 50 percent of what he has heard *immediately* after he has listened to someone talk—no matter how carefully he thought he listened. A couple of months later he is doing well to remember 25 per cent of what was said. There's more truth than fiction in the saying that we are a nation of "half-listeners." Perhaps it is high time that we stopped making the art of listening the neglected stepchild of education and take another look at reading, education's favorite son. For the fact of the matter is that the average adult spends 45 percent of his communicating time in listening. The remainder is divided up among reading, writing and speaking. In this world of telephones, radio, critical conferences and trial by jury, we can ill afford misunderstanding of the spoken word.

There is still another problem in human communications, however—and this perhaps is the most perplexing problem of all. This is the lem of words. There are some 600,000 words in the English language. Most of us readily recognize only about 20,000 of these. In normal conversation, we use 8,000 at the most.

By definition, communication is "any process involving an encoding, a transmission, and a decoding of a signal." In the spoken or written language, our mental images are encoded into words, transmitted by sound or sight waves, and decoded back into mental images. If the sender and the receiver have a common understanding of the words used, the communication process may be fairly complete. But, unfortunately, with the dubious exception of mental telepathy, there is no known means of transferring a thought from one mind to another that is not, at best, imperfect and at worst wholly inefficient and unreliable.

Let's take, for an example, a fairly simple word like "fast." Everybody knows what we are talking about when we say "fast." Or do they? A *fast* horse is one which runs rapidly unless he is tied *fast* and then he is not *fast* because he is *fast*. On the other hand, a color is *fast* when it doesn't run at all. If we observe a religious *fast,* we abstain; and yet, not too long ago, we were saying that young ladies who abstained from practically nothing were considered *fast*.

So you see, when our listeners disagree with us most violently, perhaps we should look back at the words we used and find out what they thought we were really talking about. First we must realize that words are only *symbols*—they aren't actually the things they describe. This isn't so much of a problem in the use of concrete words like "tree," "deer," "land," or "farm." When we say "tree," our listeners probably get a mental picture of some kind of tree. Of course, it may not be exactly the tree we had in mind—but at least its a plant with a trunk, branches and a lot of leaves. But what happens when we use abstract words like "sustained yield," "management," "carrying capacity," and "conservation." What mental picture do these words evoke in the listener? When we tramsmit, in oral or written form, the word "conservation" to the American public, can they as individuals or as a group arrive at any common meaning and understanding? No, the unfortunate truth of the matter is that they can't. And perhaps this is why there is always so much confusion and controversy in conservation circles. All too often we have embarrassed, even angered, people by using words they don't understand.

The simple answer to this problem is that we must use more "two-way" communication. We must improve the quality of our message by using words that are likely to be understood—by talking or writing in the every-day language of our listeners. But, more than that, we should concentrate on listening to what they have to say. Conversations in the barbershop or bar room, letters to the editor in our daily newspapers, questions asked by letter or telephone—all these are "feed-back" clues to how much our audience understands us.

Finally, there is still another psychological trick of the trade which we should use in communicating our message to those five million steady listeners—and to all 189 million Americans. This trick involves the application of just three words—*intensity, frequency* and *recency.*

Intensity relates to the qaulity of our message, a point upon which I've already touched. But we constantly must try to improve our mesage—to make it more attractive by better, more intense application. As conservationists, it is our duty to improve our writing and speaking skills. Few of us will ever become Billy Grahams, but we certainly can try. Few of us will ever be the equal of Ernest Hemingway—but we can try.

Frequency involves the number of times we transmit the same message. How often do we repeat the message, either with the same words or better still, using somewhat different words which mean the same thing but may be understood by a different group of people?

Perhaps I can best illustrate this point by repeating the same story I used in the beginning of this presentation. Listen!

You are a conservation department employee flying in a new jet airplane between Chicago and Las Vegas. On board the plane you notice a number of businessmen and through casual conversation, you learn that each one has a different reason for boarding the flight and they each have different points of destination.

You enjoy the decor of the plane's interior—light blue with a dark aisle carpet. You are especially attracted to the two stewardesses who are dressed in blue and wear pert little hats.

There are five specific passengers who particularly interest you. As a conservation department employee, you talk first with a retired Navy captain who is going to Los Angeles. He tells you he is 60 years of age. Sitting on the aisle next to you is a 50 year old public relations counselor who is afraid of flying. The third man you talk with is a successful hotel manager, age 40, who is flying on to Reno. The other two men with whom you become acquainted are insurance executives. One is 45 years old and the other is 30. Both work in Lincoln, Nebraska, a city which holds special interest since you started your work for a conservation department there several years ago.

Now how old is the conservation department employee?

Frequency was the key to better understanding. And the amazing thing about it is that it's a rather old, shopworn key. It has been used for years by advertising agencies to unlock our poor little minds and twist us into buying the products or services offered by their employers.

Even though we may not like the constant, monotonous chant—the slogans, singing commercials, clever pictures, phrases and letter combinations that echo from every radio, television set and newspaper across our land, we certainly remember them. In fact, the first words spoken by some of our pre-school children these days are quite often "LSMFT, Daddy, It's Three Ring Time" or some other absurd commercial clause.

By frequent repetitive slogans and statements, we as the most civilized society the world has ever known are being sold product after product—some good, some necessary to our survival, but too many absolutely unnecessary to our health, happiness or peace of mind. It's high time we stole the march from the advertising agencies on Madison Avenue. After all, what better product or service is there to sell the American people than the wise use and management of our natural resources? So let's send that message across the land, into every home and heart and mind—and then send it again and again.

Last, but most important, is "recency." People act on what they have just heard—not on what they heard last year or even last week. As pointed out earlier, they probably don't even remember what they heard yesterday. Thus we must make our message intensely interesting. We must send it frequently and repeatedly. And we must constantly broadcast the word so that people will have heard it recently.

Intensity, frequency, recency—these are the keys to learning. Without them we cannot educate, no matter how much we inform. Five million readers can be wrong—but if they are, let's re-evaluate our message. There's always room for improvement in our information-education programs. We have a long way to go before any of us can claim perfection. In fact, Commissioner Dru Pippin, of Missouri, summed it up so well recently when he said, "Isn't it amazing that we now can send a message around the world in one-seventh of a second but it still takes years to get a simple idea through one-quarter inch of human skull."

Let's shorten that time gap!

DISCUSSION

MR. DOUGLAS HEY (Cape Province Department of Nature Conservation, Cape Town, South Africa): Mr. Chairman, I listened with very great interest to this paper, and I heartily underline everything the speaker said about the five million readers. Our problem, and one about which we are very much concerned, is the fact that we can get those five million people to read, and we can get them to listen. We may not get quite the message that we would like to get out of them.

Something that has impressed me very greatly since I have been in the States is, how does one extend your reading public beyond the five million? It is easy to sell conservation to people like myself who have been out in nature, been out in the wilderness. But how do you reach those people who have never been out of the cities?

Your cities are vast, and when I see these millions of people that have probably never had their feet off the blacktop, who live in elevators, who live an artificial life, who have probably never even seen a cow in their lives, let alone an antelope—how do you sell conservation to those people? You might as well try to sell them a plot on Mars.

MR. KEEFE: That's a very good point.

MR. JOHNS: I think the answer in a way relates back to one of the basic concepts of public relations, and that is that you don't try to sell mass as such. You try to sell those five million persons and have them in turn go out and sell their friends and acquaintances and expand the circle. But first you have got to get those five million persons sold and educated and motivated to carry the word on beyond themselves to others.

MR. KEEFE: Very good. Are there any other comments?

MR. DON MILLER (Arizona): I was wondering; I am not just exactly sure who you aimed your talk at, but I was wondering, who is disapproving our program. Whose approval do we need if we are speaking of approval? And shouldn't we design our programs specifically for the people whose approval we need, and perhaps the other would be gravy, so to speak?

MR. KEEFE: I certainly think that the first people we have got to get approval of are the people who keeps us in our jobs, those who are most immediately concerned with the outdoor resources. If we don't satisfy them we are not going to be in those jobs very long. Beyond that, then we have to enlist as wide support as we can. It is obviously impossible to enlist the support of everybody. I don't even think it is necessary or desirable.

Things in this country, I believe, are moved by rather small groups, if they are determined groups and well informed. We naturally solicit the help of as many people as we can, but we still have our first audience to satisfy and win approval, and then, as Will says, through them as a nucleus, hope that we can spread our message.

Would you have anything to add to that?

MR. JOHNS: No.

MR. TOM KIMBALL (National Wildlife Federation, Washington, D. C.): I don't think that Dr. Hey really got an answer to his question, and I would like to try to field that one a little.

These millions of people that are beyond the conservation fringe are of utmost importance to our organization. Seventy per cent of the people of America live in the urban society, and are of the type of which Dr. Hey spoke. And if, as conservationists, we can't get our message across to these individuals, then we're sunk. As far as getting funds, the government organizations getting funds, to do the job of competing with industrial uses of land and water, if we can't get some support from these millions of people, then we are just in a bad situation.

I think the answer lies in doing the same thing for conservation that these Madison Avenue boys do for L.S.M.F.T. and the rest of the business. Certainly if they can sell those silly slogans to kids right on up to adults in the urban society, I don't know why in the devil we can't use those same methods and sell people on a worthy cause.

The National Wildlife Federation, in a lot of its promotion, is not aiming at you people. I don't know how many of you have seen our television spots on television, but these are 60-second to two-minute spots, and they are aimed specifically at this urban dweller. What we are trying to do, first of all, if he hasn't had his feet off the asphalt pavement, is to show a little something on the screen that he might enjoy, and then we try to do the same thing through repetition, to sink through that four inches of skull so that some time in his deliberations—

MR. KEEFE: That was a quarter inch; it just seems like four inches.

MR. KIMBALL: Some of them have four inches if you try to get through it to get a message through on conservation.

In any event, I think that it can be done, and I think it is up to the information and education people at the private level, our level, as well as in government service, to begin to further devise the media and take a page out of the advertisers' book, the Madison Avenue boys that are getting paid tremendous sums of money to sell something that's no damned good to a hundred million Americans that live in our urban society. If they can do that, I don't know why we can't do it with conservation.

MR. KEEFE: Very good.

I think this is the way. We have some complex things to sell. It is not as easy as saying "Forest fires are all bad." We know that they aren't all bad nowadays. In game areas, at least, controlled burning can be good. It is a critical concept, not easily sold by Madison Avenue techniques. And we need to find out how.

MR. KIMBALL: Well, that's true, but sometimes I think our technicians get too technical in trying to sell things.

Just to encourage people who do not now participate in or have a knowledge of what benefits come from the out of doors is one thing. One of our principal jobs is just to preserve enough space so that we are going to have some outdoor recreation in the future, and all we need is a little public support when decisions have to be made as to whether or not we are going to have a great metropolis of high-rise apartments and nothing else around it, or whether we are going to take one of our streams, and instead of damning it up and, like in California, diverting all of the water from the north to the south and not have any streams for anadromous fishing, and so on. There are many of these issues which are coming up now, and if the public understood and was sold on the benefits that are derived from participating in a quantity of outdoor recreation, then they would begin to react to preserve just a small segment of that. Otherwise, if we can't sell them, we are probably going to have to be satisfied as a nation with high-rise apartments and nothing else.

ARE YOU TALKING TO YOURSELF?

E. F. LITTLEHALES
U. S. Forest Service, Denver, Colorado

It's a real honor to be associated with such distinguished conservation education leaders as are on this panel. Most of these gentlemen are nationally known conservationists, and their comments this morning add up to some real challenges for the rest of us.

I'd like to suggest another challenging idea—as indicated by the title listed in the program "Are you talking to yourself?"

A few months ago, I saw the results of a survey made by the American Forests Products Industries which indicated that only a small percent of the American public has a meaningful grasp of the basic subject we're discussing today—Conservation. Try it yourself—the next time you meet with a group of lay people, ask them what conservation means. Nine chances out of ten, you will get the words *preserving* and *saving* as the first two definitions.

This leads directly to the subject at hand. Who have we been talking to, writing for, setting up exhibits for, showing movies and slide lectures to, for the past 60 years? I submit that much of our effort is directed toward those people and groups already knowledgeable to some extent on the over-all subject of conservation. Let's pick out a couple of examples:

Sports writers who write for the fishing and hunting magazines are writing to those who already have at least some knowledge of natural resource conservation. True, there are thousands of sportsmen who read these magazines, and you are performing a valuable service in keeping them informed of current developments, but what of the millions of citizens who don't read those magazines? And we have to admit that on the sports page, we read only the items that have to do with the sport we're most interested in.

What about those of us who are members of conservation oriented agencies and groups? What about our affiliations with other organized groups? Most foresters, for example, hold membership in the SAF, attend their meetings and take active part in programs where foresters talk to foresters about trees. How about the Audubon Society? Don't the members tend to attend all Audubon meetings and talk to people most interested in birds—about birds? And the IWL sessions—don't avid hunters and fishermen tend to gather together and talk to each other about mutual interests? These sessions are productive, interesting, informative, and enjoyable. But aren't we often talking to ourselves?

Let's think for a moment about the possibility of reducing the time spent talking to ourselves and spend the same time working with people and groups to whom conservation is a "nice" word and they're in favor of it but can't tell you precisely what it is they're in favor of.

You name them—service clubs, church groups, women's clubs, bankers associations, chambers of commerce, educators, radio and TV executives, county commissioners, librarians, labor unions—the list of possibilities is endless. How much time do we spend with groups like this? Not much, I venture to say, and why not?

One reason may be that it's harder to work with an uninformed group. You have to choose your words and ideas carefully to insure audience comprehension. It's not that they're unintelligent; it's just that they're not familiar with the technical jargon we use so freely. I once heard a young assistant ranger give a slide lecture on multiple use to a group of garden club ladies. It was an excellent lecture that had been prepared by a specialist as an indoctrination and training course for junior foresters. The ladies were most gracious, but I'm sure they left wondering what it was all about. The title of his talk, incidentally, was "Conservation," and I'll bet it is the last time *that* group ever asked for a speaker on conservation.

I once proposed a training session in I&E methods and techniques for Rangers on one of our forests. The offer was declined with the remark "We already know a heck of a lot more about I&E than we're doing. Let's not waste time with a training session." But on questioning, I found that his interpretation of conservation education was showing Smokey Bear movies to school classes in his area. While this is good, it is such a limited part of the many opportunities available in his immediate area. But it is *easy,* because teachers usually welcome a forest ranger to their classroom once a year.

It's far more difficult to convince school officials that conservation education should be an integral part of their curriculum. Yet what better place to start in this entire job than with the educators themselves? Two novel projects are getting underway in Colorado. One is a proposal by CSC in Greeley, a teachers' college, to open an outdoor conservation education laboratory for their student teachers to teach them how to teach conservation. This is going to take considerable time on the part of the wildlife biologists, soil specialists, foresters, recreation specialists, etc., to help build a meaningful curriculum for the teachers. As a matter of fact, it already has taken plenty of time and effort by some dedicated people in Colorado to plant the seed, nurture it, and assist the developments to date. But if this proposal becomes a reality, every graduate teacher will be in a better position to carry on his own conservation education program in the classroom.

The other project is an outdoor education laboratory in the mountains just west of Denver where every 6th grade child in Jefferson County has the opportunity to spend a week during the school year learning the true meaning of conservation. This, too, has taken hundreds of hours of work by men of the several disciplines involved in conservation to help train the school staff and assist them in developing useful teaching devices.

The fruits of this sort of work can be exciting. So many people are willing, yes even anxious, to work for natural resource conservation—if only they knew how! I had an opportunity to sit in on the second day of one of the recent wilderness bill hearings. There were literally hundreds of people who signed up to testify. They were sincere, dedicated people, but I was amazed by the number who obviously lacked an understanding of the basic meaning of the legislation—or even an understanding of how wilderness areas fit into the total wild land picture of this country. Certainly, here is an elite group of people who had the interest and enthusiasm to appear before a congressional committee—a group that surely would be receptive and eager for information on conservation matters.

Will we meet any of these people here at this meeting? I think not. And surely I won't meet them at SAF meetings, nor IWL sessions, nor at any of the myriad of professional or semi-technical or society meetings I may attend.

It isn't easy to break into a new group with new ideas. It takes work, and planning, and faith that in time our efforts will pay off in a public much more conscious of the need for natural resource conservation. The indirect or gradual approach is often more successful than a hard hitting campaign designed to ram sophisticated conservation information down people's throats.

In this connection, perhaps I should mention one program recently started by the Forest Service on the National Forests. Our Visitor Information Service program has been defined as an effort to "increase the enjoyment and enrich the experience of the visitor to the National Forest." Essentially, it is a conservation education program, designed to help the forest visitor better understand those things about him, that because he lacks a basic knowledge of outdoor matters, he is not in a position to comprehend.

It can be as simple as pointing out the effect that a great fire of 100 years ago has on today's forest stand. Or it can be far more complicated, such as a short self-guiding trail on Mt. Evans in Colorado that passes from a heavily forested area through alpine brush to a typical tundra zone—a lesson in ecology. In time, as financing, manpower, and ability permit, we hope to have self-guided trails set up close by every recreation area or other feature where visitors tend to congregate. If the trails, the interpretive signs, the campfire lectures and the manned visitor centers spark an interest in conservation matters, as we hope they will, the program will pay for itself in the long run.

But even here, we're dealing with a group already interested in the out of doors. And although we had millions of visits to the National Forests last year, we're still contacting only a fraction of our population with this program.

Many of you know "T-Bone" McDonald, the soil-conservation evangelist from Oklahoma. "T-Bone" has given probably thousands of lectures involving all the people in the community in this business of conservation. He gets bankers involved in his conservation programs. If they put up some money for prizes or barbeques, the local merchants follow suit. And where people put their money, their interest follows. So work with the bankers, and the labor unions, and every outfit you can get entrée to. In these organized groups, you'll find the leaders of thought and action in the several segments of the community.

Although I don't have near enough time to do all the things I'd like to do, I try to schedule an occasional evening with a group of scout leaders, or a church men's club, or a neighborhood garden club. These are refreshing sessions. I talk all day long to foresters and that gets dull. Try the new and different approach. Ask people to help you in your conservation work. Ask a favor of them to further your conservation work. Get them indebted to you a little bit—they'll have a personal interest in your work just as does the banker who puts up money for a conservation prize.

We could all take a leaf out of Gifford Pinchot's life. If he had been satisfied to talk only with his associates and the very small circle of conservationists of his day, many of us probably wouldn't even recognize the name today.

But he talked far and wide, and loud, to housewives and politicians, to lumbermen and miners, to professors and presidents. We know the results he attained in this field of conservation. We can't all be Gifford Pinchots, nor can we all talk with Presidents, but I charge that each of us *can* do more in this field than we're now doing.

Study your schedule for the next month. Where are you channeling your major efforts? To those who are already staunch supporters of conservation, or to entirely new and uninformed groups and individuals? How much time do you plan to spend next month talking to yourself?

DISCUSSION

DR. HEY: Mr. Chairman, I think it is very important to have two main goals in your conservation education work. I think the first thing to do is to stimulate an interest in nature. You can stimulate an interest in nature by just talking about nature. Nature is so profoundly interesting. You can stimulate a tremendous amount of interest by just talking about nature without mentioning the word "conservation."

Once you have your people listening, then you can start in with your conservation education. That is what we have done. Recently we started a program for looking at nature, where we get a group of people just to discuss nature without plugging conservation, and gradually we bring in the conservation angle. We find that that is a very fruitful way of working with the uninitiated.

MR. KEEFE: This is what you said about the indirect approach.

GUIDELINES FOR CONSERVATION ACTION

STEWART M. BRANDBORG
Associate Executive Director, The Wilderness Society, Washington, D. C.

Conservationists—both professional people and part-time workers—have much in common in their concern for making the world a better place to live. Their purposes and ideals are a bond with people everywhere who are concerned about the future of Mankind, and who are willing to meet the problems in preserving those values that give meaning to our lives.

We recognize now that our problems in conservation are more than biological; they are sociological, economic, and political. We have witnessed the gradual development of a conservation conscience that has given a fresh impetus to the movement. But we have not yet realized the full implications of our greatest challenge, our work with people in causing them to appreciate Man's relationship to his living environment. If one fact stands out it is that creating a sound strategy for working with people and giving them proper guidance must become the main focus of our efforts.

THE COMMON GROUND

In working to attain a desirable balance between human populations and the lands and waters upon which we depend, conservationists face a challenge that is not greatly different from the challenges to those in other areas of broad social concern. We share many of the sympathies and motivations of those who work to feed and clothe impoverished people, to find homes for the homeless and half-starved children of the world, to provide educational opportunity and technical training for poor and underdeveloped nations. Most of these worthy causes find us concerned and sympathetic.

Within the breadth of our concern for people and human needs in the conservation field, we have much in common with the host of people and organizations who are absorbed in some worthwhile public cause. These groups, by their number, the variety of interests they represent, and their influence, have become a clearly recognized phenomenon of our modern democratic society. They have sprung up in the manner of most conservation groups, following a clearly established pattern in which a few people come together to discuss a problem or need that they recognize is not being served adequately. Their decision to do something usually results in the formation of a new organization. The range of the interests of these groups is as broad as the rapidly expanding frontiers of human knowledge; their preoccupations extend from the field of religion—in its many forms and applications—through the expansive spectrum of modern politics with its multifaceted interpretation of the public's interest. It is within these public service organizations that we must seek the guidelines and patterns for our work.

IMPORTANCE OF "THE CAUSE"

In nearly every instance the citizen organization—whether political, religious, or social in nature—depends for its success (and to a large extent for its survival) upon its ability to satisfy the basic human desire of most of us to contribute something worthwhile to our society. Thus it serves to offer the individual the personal satisfaction of feeling that the world, or at least the part of it in which he finds himself, is the better for his having been there. Aside from their particular organizational purposes and the opportunity they provide for fulfilling the need most of us feel for social contact, our organizations have one characteristic in common: they meet the basic requirement of the individual to satisfy what he regards in his personal perspective as his obligation to help resolve certain of the human problems and social ills upon which the organization focuses his attention and for which it asks his help. The most successful groups are those which succeed in getting their members most actively involved in a cause that satisfies the demand made upon us by our social consciences.

The more successful the organization is in training its leaders and in giving them guidelines for solid accomplishment, the more successful it is as a working entity and as an influence in the community. Conversely, the groups that fail in giving purposeful "social leadership" are likely to succumb. The mortality rate among citizen groups is startling, even when viewed in comparison to the large numbers that continue to spring into existence.

The plight of the community organization that "dies on the vine" can be attributed usually to its failure to give its members a sense of accomplishment in working for worthwhile goals. Sometimes this occurs when there is inadequate leadership in the organization.

Quite frequently in conservation groups the effort to stymie the worthy program of an organization is intentional, carefully organized, and well-financed by those who stand to lose through reforms which would result from enlightened and aggressive conservation campaigns. There is a constant surveillance of an active citizen-conservation group by business and "bureau" interests who, if not seeking to maintain a control over the organization through the manipulation of its "human wires," certainly do strive to keep it within a controlling influence that will best serve their own purposes. These may, or may not, be identified with the public good, but in any case such controls are hazards to an organization's own effectiveness.

OUR SUCCESSES AND FAILURES

Our successes in conservation have been realized when we have clearly defined important issues and when we have given them meaning in terms of the public's interest. Citizen organizations have played a vitally important role in these efforts. We have experienced our defeats when we have allowed the issues to be obscured, poorly defined, or have faced other difficulties in communicating to the public in the time in which we have had to work.

Many eloquent and deeply moving statements have been made in our conferences over the years about our failures and frustrating setbacks in working toward important conservation objectives. We demonstrate a proclivity for what some refer to as "conservation handwringing." To a large extent this is an inescapable part of our mission as we play out our roles as the defenders of the public interest in protecting the natural resource base, and we may well recognize that too often we have been forced to meet too many problems and to fend off too many attacks on the Nation's resources at one time.

We are not wanting for challenge; most of us maintain mental lists of the conservation urgencies that we would wish to pursue if given the required time and money. Few practicing conservationists lack ideas for worthwhile programs that need to be pursued expeditiously. We each have a varied assortment of these, too large a part of which seem to be "high-centered" because of the lack of support they receive within our state and national legislative chambers or elsewhere in the body politic.

THE ARENAS OF CONTROVERSY AND POLITICS

If one lesson stands out above all others in our present practice of conservation, it is that we had better equip conservation-minded people as quickly as we can to operate effectively in the legislative and political arenas. This involves giving our leaders, and those we hope to recruit for positions of leadership, clearly defined issues that will serve as rallying points around which the forces of political action can be brought to bear on the major conservation challenges of the day. These forces must represent the actions of aroused citizens who know and understand issues clearly and who serve the cause of conservation with dedication and a devotion to the public interest.

Neither the citizen leader nor the conservation educator can any longer afford the esoteric luxury of confining himself to the teaching of the fine principles of resource management. If too many of us continue in this pattern, we shall continue also to witness the steady depletion of our resources without recourse to the social and political channels through which we can gain support for needed reforms and sound programs. Our "hand wringing" will increase in its intensity but we shall accomplish little in showing people how to stem the tide of the resource raiders.

While none of us would minimize the basic importance of conservation principles for land and water use, these are not likely to become fully meaningful to the conservation-minded person, or the citizen whose leadership we wish to recruit for conservation, until he sees their application in meeting an actual resource problem that he faces in the "true life" setting of his own experience. It is within the arena of social and political action that he can best be guided by these principles in a way that will give him appreciation of their full value in doing the conservation job.

We should carefully avoid the tendency of many professional conservationists to retreat to the "safe ground" of noncontroversial principles and broad educational efforts while abdicating to a small group of private organization professionals the leadership role that each of us must play in applying these principles to conservation problems. A special effort must be made to gain involvement on the part of citizen leaders at national as well as state and local levels on behalf of constructive—but very often highly controversial—conservation issues.

Many people can be interested in conservation if they are shown the relationships between it and other endeavors for human betterment. The population explosion demonstrates the plight of Mankind in a most dramatic way by pointing up the need for holding human population in some kind of balance with the physical environment and resource base. This problem is of such immense proportion that it will require the involvement of leaders everywhere, in this country and throughout the world. Yet, how many times recently have the evidences of this—the industrial blight, suburban sprawl, congestion, crowding, and other afflictions of big cities been related to this problem. Some 80 percent of us now spend most of our lives in crowded urban areas, but how much real attention are we giving to this question? How effective have we been in relating it to our local conservation need?

The problems are with us in the city just as they are everywhere else throughout the land. Our big task is that of dramatizing them in a way that will involve people in our conservation battles. More people than we realize are ready for the fight and are ready to become part of this movement.

FORMAT FOR CONSERVATION ACTION

Most of us have had the experience of watching a small group of people succeed in putting over a needed conservation reform. Whether this occurs within a local jurisdiction, a state legislature, or the Congress of the United States, the same elements of social action, human effectiveness, and dedication to ideals are represented. The opportunities that each of us has had on such occasions to witness the success of a group of people who know what they want and then go after it, reaffirms our faith in our system of government.

People—even only a handful—can still get things done in this country. Most significant in the present circumstances of our Nation is the fact that many people are becoming increasingly disasatisfied with the way things are going. Apathy, as we so often have described it, as a deterrent to democratic processes and the worthwhile things we strive for, has given way to a restiveness and stirring in people's minds which we must exploit for our public purpose.

In an editorial in the *Saturday Review* of December 2, 1961, Norman Cousins described this change in these words:

> "For years the most persistent complaint about the American people was that they were apathetic. Let the lament cease. The apathy is no more. The prime fact about the American temper today is that the people are exploding out of indifference. They no longer have to be pushed or prodded into an awareness of needs and dangers. The national preoccupation with tailfins and large

TV screens has given way to a sense of national and personal peril. Exit easy drift; enter apprehension.

"The end of apathy, however, has not led to any united resolve or steadfast pursuit of clearly understood objectives. Instead, the treadmills are in furious operation, accompanied by flailing and thrashing. The danger has produced insecurity and exasperation rather than purpose, In fact, the country is precariously close to an anxiety neurosis. The recognition of danger is exceeded by the feeling of uneasiness and confusion."

Mr. Cousins goes on to define the negative influences that have caused some of our people to engage in condemnations, pressure, and even terror tactics that have taken such a devastating toll of our Nation. But he returns to his thesis that more people than ever before "are eager to explore ideas, to read and think and discuss." He emphasizes that they are "hungry for better information than they seem to be getting . . . that they want to act; . . . that they would like to be responsible and relevant." But he hastens to add, "they don't know where best to take hold."

We conservationists should address ourselves deliberately to those who thus see themselves showing encouraging signs of concern for future betterment. We have much to work with in the leaders of conservation and other citizen groups who are already experienced in enlisting public understanding and support of needed programs. Yet, we should be on guard to avoid the hazard of letting our American preoccupation with large organizations and their encumbering superstructures prevent us from doing our job with people. All of our public and private agencies must be encouraged in every way to contribute to the stimulation of the unstirred conservation conscience of people. Our job is not one that requires, at least in most instances, any new organizations or further proliferation of the ones we have.

Mr. Cousins made a strong plea for what he called a Society of Individual Responsibility, with local chapters throughout the country. These, where they have been started in various places over the nation, follow the same creed: "In a free society the individual is responsible. He is responsible for what happens to that society. He is responsible for the decisions the government makes in his name or for its policies and actions, its decisions or indecisions. Therefore, he has both the need and the right to be informed." How appropriately this definition of the individual's role seems to fit our requirements in conservation.

The Society for Individual Responsibility has no national officers or directors. It has no dues. It does not exist as a formal organization. Its sole purpose is to provide a responsible outlet for individuals who would like to make a personal connection with what is happening in the nation and the world in a way that may count for something Ideally, each unit of the Society consists of no more than twenty or thirty persons. The activities of a unit are divided into two broad categories. One category deals with information, the other with action.

Applying these approaches within the conservation sector, workers representing themselves, and already existing conservation and citizen groups, can be assigned to task-force fact-finding units. Three or four members assigned to a team would work together and study source materials and literature on a subject, view the problems in the field with representatives of public agencies most directly involved, and return to their unit-at-large and their parent groups with their reports.

ORGANIZING TO DO THE JOB

The type of organization that is designated as the clearing-house for the coordination of such a program is not of primary concern. It may be an informal, action-oriented committee or a council made up of aggressive citizen leaders representing their respective groups. There are distinct advantages in using the council type of organization, which can usually make available the relatively small amounts of money required for this type of effort. The group must be free to act responsibly in and of itself and to serve as an effective disseminator of information and the needed calls for actions back to the parent organizations and their memberships.

In two western states, Arizona and Montana, effective study and coordination of their conservation programs have been accomplished through the conservation council type of organization. There should be serious study of the rather flexible organizational patterns of these groups which has permitted effective coordination of their educational and action programs.

One section of the By-Laws of the Arizona Council seems particularly prudent in view of the ever-present hazard of internal organizational interference from economic pressure groups. These are the same crews of vested resource raiders with whom we contend in most of our battles, the people who too frequently are so successful in their infiltration of conservation groups that they can stall effective efforts at critically important stages when the battles can be lost so easily through delay or hesitation. The Arizona Council limits its membership to bona fide citizen groups and requires that member organizations devote " . . . a substantial portion of their efforts to conservation and . . . adhere in principle and in practice to the conservation and preservation of the natural resources, historical sites, and scenic beauties of the State of Arizona." The by-laws state that, "No person or organization shall be entitled to any membership or representation in the Council, which person or organization is concerned primarily with commercial use of the natural resources of Arizona." They further require that, "No person or organization shall be entitled to membership or representation in the Council who does not truly subscribe to the objectives of the Council . . . nor to the basic and underlying principles of conservation."

SOURCES OF GUIDANCE

Responsible information can lead to responsible action. The kind of responsible action most needed today takes the form not of denunciation or threat but of working support. Men in public conservation agencies need evidence of constructive support for constructive policies. Too much of the pressure today is on the other side.

Dissatisfaction of the people in this country who will quickly develop, if given the opportunity, the kind of conservation conscience of which we in conservation speak so idealistically, is one of the greatest potential sources for this constructive support. Restiveness in thinking people presents to us an opportunity to develop public awareness. More and more people are repelled by the destruction of our scenic landscapes, our remaining wilderness, our wildlife living places. They abhor the wastefulness that characterizes the too commonly accepted definition of economic progress. They are ready to move, if we within our private groups and public agencies will give them their bearing and the "spark of leadership" they require to start on their way.

The greatest need of these people is the "how to do it" guidance that we can provide them in attacking problems of which they themselves can see the full importance. They will get their best initiation and experience by working on these in the home community and state.

The role of the conservation-educator of the private citizen group or public agency must be that of the consultant and catalyst. He should serve to define issues and problems so that they are readily understood. He should be a source of factual information, general guidance, and suggestions. His respect for the independence and autonomy of the citizen committee or organization should be rigid; he should avoid imposing his judgments on the group, or influencing its decisions, without providing a full opportunity for a review of all of the facts after hearing from both sides in any controversy.

The citizen or agency professional who fails to adhere to this policy places the citizen effort in jeopardy. By imposing his judgments on the group, he wilfully substitutes his preconceived determinations for the conclusions that would otherwise grow out of objective study and discussion by members of the group. Instead of developing the confidence and self-reliant leadership with individuals, the group succumbs to the "one man band" influence that is so prevalent within many of our organizations today. Such domination of action groups by an individual or small clique has a stultifying effect on the organization; it diametrically opposes and serves to obstruct independent thinking and actions, the delegation and sharing of responsibilities that are such an important part in the development of the individual's competence and confidence in himself as a leader.

BUILDING OUR LEADERS

Much has been written about leadership and the training of people in a way to assure a continuing source of it. Perhaps the most important indgredients for leadership are those that call for use of old-fashioned "horse sense" in getting along with people. This, of course, involves getting to know and appreciate the individual, and the ability to guide his efforts along constructive courses. There are excellent materials available that provide programs for development of leadership. This is a highly important function of the action committee and should be a priority concern in maintaining a continuity in its efforts through the years.

We are generally aware that most of the good things which are accomplished in this country are brought about by a few people. The much flaunted majorities are elusive. In conservation, as elsewhere, they seem to spring from the seeds cast by the few who serve the cause with a zeal and a dedication that come from working for something that is bigger than themselves and bigger than their personal gain.

We have seen many instances in which a few far-sighted conservation leaders, people who know how to work for the cause, have pulled immense chestnuts out of the conservation fires. If they are flanked by a few dozen like themselves who share their enthusiasm, there is little that remains beyond their reach. This is true everywhere and at all levels—in the local community, the state, and the nation. At each level we face a critical need to apply leadership skills within the citizen groups and public agencies who can train people in this important work.

As a matter of defining our basic approaches, we should recognize that we seek to instill a confidence in people that they themselves can bring about changes for the better in this system of ours. This is our great opportunity.

We must always be ready to counter the defeatism of the individual who tells us that we are wasting our time, that all of the decisions are made before the election returns are in and that among big business, big government, big labor, and the paid lobbyists of powerful economic and pressure groups, there is no longer a way open to the ordinary citizen who wants to make himself heard and his influence felt on behalf of the public interest.

As we know so well, most worthy goals in the conservation field bring out our opponents and point up the need for evaluating their role. They come out in force. In comparison with our modestly financed private conservation groups, they have large staffs with plenty of funds to use in holding back essential conservation programs. The thing that they lack, and that they always will lack, is the one thing that in the final analysis leaves them so short: the dedication of people who are working for a public cause, for something beyond themselves. The dominant concern for grinding their own axes is their great burden. In standing to be counted as representatives of their own self-interests they suffer the loss of any continuing support from the public. This one difference between their leadership and ours is the difference between self-serving profits and a broad concern for the public good.

In giving direction to people who will serve the conservation cause through their own leadership, we engage ourselves in an operation in which we help the individual citizen exploit the full prerogatives of his citizenship within a democratic society. If we fail in our endeavor for the public good, so may the system.

Throughout all areas of human achievement, discouragement, and the disappointments and frustrations suffered in working for long-range goals, can take an incalculable toll. Conservation is no exception. Our skill in counteracting these by rebuilding our own and each other's enthusiasms so that we can "pick up the pieces" and resume our efforts is a true measure of our social maturity and our leadership, in the realization that we work with and for people and the spirit of the human being. This maturity and skill and realization will determine in the final analysis whether we will persevere to get the job done.

ENLISTING PUBLIC SUPPORT FOR CONSERVATION

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The effectiveness of information-education work can not be measured in concrete terms, only in concrete results. Perhaps the only true way the information specialist or educator can detect success in his efforts is when members of the public cite his own material back at him. When people adopt his views as their own, then he has made a "sale" for conservation.

As representatives of a private conservation organization, we know that conservation must have public support to succeed. Cleaning up of water pollution, scientific game management, adequate provision for outdoor recreation—the completion of these and other vital conservation programs should be the ultimate result of good educational efforts. Public apathy and continued mismanagement of natural resources must be attacked. Obviously, much more work needs to be done.

To do the best job possible, I-E people would be wise to evaluate their own programs in the harsh light of public acceptance. They should examine their motives or objectives, their methods, their results. They need outside help in this evaluation.

Professionals constitute the core of conservation work, the sound bases for successful programs. The professional, however, must recognize realities—the system under which he works directly affects his efficiency. The highest administrative official at almost any level of government is subject to pressures of all sorts, political and otherwise, He is subject to suggestions that specific problems be handled in particular ways by certain people. Of course, the administrator's responses to these demands filter down through and out into the field of operations. Conflicts arise. Issues are joined. Professional "heroes" who fight the system may find promotion difficult and, in some cases, a tenuous tenure.

I mention this fact because resources management is tied quite closely to people management. And, in our opinion, the enlistment of public support for conservation usually is the factor which determines success or failure. A principal task of I-E personnel is to guide this enlistment, bringing responsible citizens into support of the conservation program. It goes without saying, however, that any I-E effort which cannot be tied directly to solid, well-defined, long-range objectives is mostly a waste. It is difficult to "sell" work of an agency which bends its policies to please a politician or some other powerful individual.

A vital part of the educational process is to recognize that these realities of the "system" exist, even though they may leave something to be desired. Colleges and universities should stress the need for human management at the same time they impart technical professional training to future resource managers. A fisheries biologist, for example, should prepare and educate the local people concerned in advance of any widespread stream or lake poisoning program. He might not only escape the fury of righteous wrath but could learn that so-called trash fish often are held in high esteem by some of the people he serves.

Fortunately, some schools now are recognizing this need for enlisting public support on behalf of conservation. This is being reflected, in turn, by greater public acceptance of the competence of professional game and fish managers. However, there are schools which fail to instill their students with common sense. Some even set the worst possible sort of examples by being subject themselves to pressure groups, often the biased commercial users of public resources.

The private conservation organization performs an important function in bridging gaps between professional resources managers and the layman. In short, organized citizen groups such as conservation clubs can be of tremendous value in enlisting overall public support. Once made members of the team, these people can be valuable allies. Unguided, they can become real millstones around the necks of administers of any program. Missionary work by professionals in meeting needs of these people, even if performed on their "own time," can pay rich dividends.

Enlisting public support requires the finest of skills put forth with the greatest finesse. And, as with most contacts with people, considerable patience and understanding also are desirable attributes.

Agencies with the least public relations problems usually tie I-E efforts to specific management projects, rather than harmless, general policies. The best situated agency anticipates a problem in advance and directs its I-E efforts toward softening the contact before the actual project, change, or regulation becomes effective. Consequently, the tie between planning, operations, and I-E work must be so close as to be almost indiscernible.

Personnel of I-E programs must use discretion in enlisting public support. At times a choice must be made between a total good for conservation and the welfare of the agency, or its personnel, at the particular moment. Can the public's confidence in professional management be shaken over obvious drum-beating to "sell" the agency? Is there a motivation to quarrel with, or harass, deliberately another identity of government in the same or similar business? Do jurisdictional disputes hamstring conservation efforts? Some agencies pursue the fine and delicate art of offsetting one pressure group against another, thus allowing its program to proceed unaltered. And, this is quite all right as long as conservation is served, rather than any bureaucratic aims of the agency.

Official I-E programs may appear impressive yet still some examination is merited. Everyone agrees on the value of magazines, publications and press releases—of movies, of television and radio releases. Both the quantity and quality of the mass media approach is increasing. Conservation education concepts are being taught in more and more schools. Yet, in retrospection, are these efforts accomplishing the conservation job? Are I-E people really enlisting the necessary public support? Perhaps, in some areas, but gaping voids in the essential "follow-through" exist even in the best of programs.

In our opinion, large numbers of individuals must be active in well-organized groups if conservation concepts are to become realities. Action by citizen groups is basic, yet many I-E programs only skirt the edge of this vital area. *To sum it up—unless professional resource people* (including I-E personnel) *help improve the leadership of interested, volunteer, citizen groups, public apathy will prevail.* This applies to both the quantity of leadership and to the quality of leadership. Possible resentment of laymen towards professionals is no valid excuse.

Capable laymen can be recruited by professionals for invaluable service. This need not be obvious. All of us know capable, highly-respected individuals who can be recruited into volunteer conservation service. Many prime prospects are professionals in their own fields—physicians, dentists, attorneys, veterinarians, bankers, etc. (Note—at one time, the nine citizens on the Tennessee Game and Fish Commission included two physicians, two dentists and one pharmacist—it was downright dangerous to yell "Doc.")

Public acceptance of conservation concepts would increase appreciably if only a quarter of the professional people in resources management today would recruit and maintain a single capable layman in a number of organizations with national affiliations. Seek out the community leaders. If they don't volunteer their support, invite them! If you want something done, ask a busy person!

There is an important reason why many highly capable people are not active in the conservation movement—they haven't been asked in a direct person-to-person manner! Experience here indicates that busy people must be approached with plausible programs. Asking them to perform specific jobs that need to be accomplished will get a customer quicker than vague platitudes and vigorous arm waving.

Suit the person to the task. It is easier to ask a person to do something he wants to do, and in which he has particular skill, than it is to talk him into foreign assignments.

We'd be naive if we fail to mention that there are organizations of volunteer workers which seem to have no place for busy community leaders. Indeed, many conscientious and effective conservation workers have been driven out of groups due to selfish, short-sighted attitudes. Some groups have traditional habits such as only allowing people who have endured years of club attendance to hold local or offices on the state level. Fortunately, there have been some gains in goals down through the years in some communities.

Although the element of human failing is most important—and often annoying—it need not be a complete stumbling block. Professional conservation workers who assume a defeatist attitude about this problem do themselves, and more important, their life's work, a great injustice. There are several approaches to this problem. One way is to encourage skillful leaders to join and remold existing groups which may need revamping. Frankly speaking, this is an infiltration but it carries no stigma. When a sportsmen's group is improperly led by a handful of sincere but mis-directed individuals and followed by passive club members, the situation can only be corrected by people with background knowledge and proper application of leadership ability. While a few individuals may resent any change in leadership whatsoever, the bulk of the crowd will eventually applaud changes for the better. Failure on the part of I and E people to deal with this kind of a situation can result in no effective support for any program and, indeed, the antithetis may come about.

In exceptional cases it may be necessary to initiate new organizations which would set examples of efficiency and enthusiasm for others to follow. Attempts to start super-organizations, groups with closed or carefully-selected membership and rigid control, often fail to work out as expected. Usually the problem isn't that of keeping out the less desirable people. More often the problem is maintaining a core of capability by persons whose first interest is conservation.

We should view citizen-type conservation organizations in the light of their potential rather than what they may have been in the past. Past methods are not going to be good enough to solve future natural resource problems. There is need for organizations which have ample positions for everyone who wants to do his duty for conservation—be the contribution financial, active work, moral support, or all of them. A few state-wide organizations, affiliates of the National Wildlife Federation, and some other national organizations, have long recognized the individual in state level activities. Most groups only allow participation of individuals on the state level through being delegates of local clubs. Experiments now going on in this field indicate that combining the two, giving the bulk of the voting power to local clubs, but allowing individuals the privilege of the floor and the right to vote, may have a number of distinct advantages. The idea is to attract, by every means possible, people who materially add to the prestige and intelligence of the organization. Where they are viewing it first hand, this effort to open up the membership is generally receiving praise by professional resource management people.

Effective action programs by organizations can be developed through proper leadership training—if leadership material participates. This is where recruitment is important. Cannot we benefit from experience of agricultural extension people in developing public leadership? Cannot we gain from the examples set by the Corps of Engineers in molding local public opinion on behalf of their projects? Leadership training must spell out the role of the citizen, detailing what he can do to convert controversial conservation issues into realities. Creating an appreciation for scientific management is only half of the job.

Leadership training must be pointed and practical. This includes frank talk about politics, because most conservation projects are tied in with governmental programs. Workers from all major political parties or factions should be invited to show how the public's interest in conservation can be served through our political machinery and policies. In some situations, it may be necessary for citizen conservationists to actively enter politics in order to protect the programs. It goes without saying that individuals are the most effective when well organized. Organizations get money. Money often can buy leadership.

Fortunately, some state wildlife administrators are examining more critically their agency's role in enlisting support of citizen groups. Some realize their "strong right arms" need the muscle which informed, vigorous citizen leadership can provide.

A common criticism of state wildlife agencies by sportsmen's clubs is that the professional personnel only show great interest in organized sportsmen when they want something or need help. The broad offer of help by the fish and game agency to sportsmen's clubs is meaningless because humans most often fail to respond to such broad generalities. If departments are sincere in wanting to offer aid, they should get down to specifics about what they can do. Departments might specifically assign someone to be the official liaison officer with the state-wide group or groups most clearly identified with fish and game interests. Whether the action is official or off the cuff, when citizen groups and commissions and departments have a team action going for them the results are very satisfying to behold. This requires cooperation far beyond the I and E division itself. Without this spirit of proper rapport on both sides, I and E people simply cannot get to the core of conservation.

And, how about research in I-E work? A number of problems need the eye of inquiry. What is the best method of locating capable, volunteer workers in conservation? What sort of organization will atract community leaders into conservation work? Are our present I-E techniques and procedures effective? How can they be developed for effectiveness in the future? Can methods successful in molding public opinion in other fields be adapted to conservation? Answers to these could be of material help in enlisting public support for conservation.

Finally, I-E people can do well to see if their programs are enlisting all potential sources of public support. The League of Women Voters is quite active in water resource problems at all levels. Garden club groups are concerned with water pollution control, indiscriminate use of pesticides, and some other conservation problems. Many citizen service clubs and veterans' organizations have conservation committees. Here are leaders. Here are areas of interest. Efforts of groups such as the Natural Resources Council of America and the National Wildlife Federation to correlate conservation activities at the national level need to be brought together on the state and local levels. The National Wildlife Federation, and its affiliates, encourages the development of active conservation councils. Professional wildlife agency personnel, particularly I-E people, are in excellent positions to develop this coordination. One simple method is for professional and layman conservationists to lunch together regularly without a formal program.

Citizen-type organizations time and time again have proven that their efforts can pass conservation proposals before national and state legislative bodies—if they are united. They also swing potent sticks, on occasion, with executive agencies. But not all of them have good records. Private organizations can share much of the blame for not enlisting public support for conservation. Successful groups make conservation the major objective, with honor and credit and personal prestige for its members a secondary consideration. Such groups welcome capable and dedicated leaders at all levels of operation and put into action any and all ideas which promise to accomplish the mission. It is up to everone, layman and professional conservationist alike, to conduct himself insofar as he is capable to the creed of making America a better place for future generations of Americans.

DISCUSSION

MR. KEEFE: That was very good, a hard-headed or hard-nosed approach to some of our problems. Are there any comments on that?

MR. PHILIP BARSKE (Wildlife Management Institute, Connecticut): I have been combining Stewart's paper and Bill's here They both used words that are somewhat synonymous. Take Stewart's "action group" or "action committee." I happen to know Norman Cousins. He is an action person, if you know him. Bill's is the citizens' group, and the shotgun approach to this program.

With the two types of groups I think we have tossed the shotgun away in some areas and have used the old bow and arrow for a target. I am referring to some of the dynamic action groups of citizens at the target point, such as the Town Conservation Commissions. They started in Massachusetts, Connecticut, and Rhode Island. Massachusetts has 300-some-odd towns. Over 20 have official Town Conservation Commissions, duly appointed, with full authority. Some of their authority is that of a miniature conservation department. I don't say fish and game, but conservation—resource oriented.

I happen to be on one in Connecticut. It was formed illegally, before our State Legislature allowed us to do it, because we had a local town program. Federally and state-wide they could not help us. Since then it has become a real entity and Connecticut has, I should say, forty-five. But that is the approach of getting it down to the community, community status, and the people are actually fighting to get on these town conservation commissions, and I make the prediction here that particularly in the East, in the areas where we have heavy concentrations of people, the town conservation commission or committee concept is really going to town.

MR. G. M. BRANDBORG (Montana Conservation Commission, Hamilton, Montana): I represent two citizens' organizations, one the Sportsmen's Club and the other the Montana Conservation Council. The Montana Conservation Council has been long in existence; I think it is one of the oldest in the United States.

My remarks confirm what the gentleman just said, but there is a lay group, and we discovered early in our history that we lacked the techniques to accomplish and take the offensive that Tom Kimball first mentioned that I think we must take.

Now, realizing those responsibilities and the fact that neither the private, nor the public, nor we as the citizens' group possessed the skill and talents to energize, mobilize and stimulate the public, we turned to the professionals—and I have a question in relation to this that any member of the panel may answer; as professional conservationists I want to ask you this question. Do you realize and appreciate the place of the philosopher, the sociologist and psychologist in developing the kinds of programs that we must develop to capture the imagination of the people and take the offensive that Tom Kimball indicated we must take?

I ask that question. Do you recognize the need for the place of the three skills that I mentioned, the sociologist, the philosopher and the psychologist, in developing the skills and talents that will capture the imagination of the people that we must capture?

MR. KEEFE: I would like to say this. I believe all of us will admit we are philosophers, but I don't know about the other two categories.

MR. REAVLEY: I did mention that research was sadly lacking in this entire field, and I believe every one of the skills that you mentioned should be examined. I might go one step further and say that in my experience it is extremely difficult nowadays to get any group out to a local evening meeting of any kind, and I believe it is going to become more difficult in the future, and I believe that we are facing great social changes today. We are going to have more leisure time and it is going to be easier to do things that are easy and more difficult to get people in to do things that are unpleasant or difficult, and we do need a great deal of research in many, many ways to get this job done.

There is another point I would like to make about this. I believe citizen-type groups often give much more credulence to group action than we do to individual action. I have a couple of Wildlife Federations now allowing individuals to work in conservation work on the state level, not having to go through all the chairs in local sportsmen's clubs and having a vote at the annual meeting. Professionals in these particular states are pleased with these kinds of approaches, and indeed the professionals are coming to these meetings and voting as anybody else.

MR. KEEFE: Stewart Brandborg has a comment on this point.

MR. STEWART BRANDBORG: There is an ultimate in one conservationist speaking to another, and perhaps this demonstrates it.

I think the question that Mr. Brandborg has asked is pertinent. I think that many of us now realize that our horizons in conservation are not as broad as they should be. Many of the professionals that are here represented recognize that we must give the professional national wildlife resource worker the background that will permit him to do the job in these social and political arenas. This is basic to our training of people, and we are suffering because we do not have an approach that is sufficently broad to enlist the people that we want to get into the various things that we are working for.

I think Phil Barske's observation well illustrates the fact that we should not be preoccupied with what type of organization we use. Rather, let's use the organizations that are already there, without too much further proliferation. Where you have interested people they should be mobilized, and as a rule they are very anxious to have any leadership, any of the how-to-do-it suggestions that can be offered by the professional conservationists.

I think it is very important, as Mr. Reavley pointed out, that the professional conservationists within our public agencies as well as the private groups carry on this work. Their numbers give them the opportunity to do a thorough job, while those in the private organizations in their small way can add to this. They do not have the people in the field that can do the people-to-people work that we so badly need.

MR. KEEFE: Thank you, Stewart, for those comments.

I might say that in Missouri last year we tried in our rather halting way to find out something about our readership in the magazine. We sent out a little questionnaire asking two questions, asking "Which article in the magazine did you read?" and "Which article did you like best?" We were a little nonplussed as to how to evaluate the information we got back. We had one article that was liked best by a third more than those who claimed to have read it. This bugged us a little bit.

MR. CHAMP KING (Oregon): I have been interested in the conservation movement as a layman for a little over twenty-eight years now. I think the toughest problem, the toughest job that I have had, was to get the educated or the agency people to attend the various meetings. I have attended meeting after meeting, and I believe I am recognized. I am a life member of most of these organizations on the back of my shirt, so that it must have been appreciated. Even the shirt was a gift from the Big Game Committee of one of the local organizations.

I used to tell them, "I will entertain you, but while you are here to hear the entertainment, believe me, I am going to preach to you about conservation for a few minutes at every meeting."

In the last two years we have succeeded in getting from two to five agency people members of our individual sports groups. They will come to a meeting; perhaps they won't be questioned at all. On the other hand, we get into some technical problem and we immediately turn to that agency man to answer the question so that we will know what we are doing when we finally come to a vote on it.

MR. DON MILLER (Arizona): Who do you think should define the qualifications of our professional conservationists?

DR. PAUL A. YAMBERT (Wisconsin State College, Stevens Point, Wisconsin): My paper will touch a little on that.

IS THERE A NICHE FOR THE GENERALIST?

PAUL A. YAMBERT
Wisconsin State College, Stevens Point, Wisconsin

Since the term "generalist" is capable of eliciting reactions ranging from nods of approval to snorts of disapproval, it seems appropriate to state clearly what is meant, and what is not meant, by that term in the context of this paper. The resource generalist is not to be confused with the generally, or liberally educated person; although the two concepts are by no means mutually exclusive or incompatible. Most wildlife management professionals would agree with Gabrielson (1959) that "wildlife management is much more the management of human activities than it is the management of the wildlife itself." Graham apparently had a similar, but broader, concept in mind when he decried the fact that "for professional leadership in resource fields we have leaned upon technicians—men and women who have received their education almost exclusively in the specialized field in which they are employed." (Jarrett, ed., 1961). Graham added that " . . . we are probing possibilities of turning out more rounded graduates in resource fields by adding studies in the humanities that are superimposed on the years of specialized technical training." (op. cit.).

It is clearly manifest that resource problems must be, and will be, considered in the broad context of the social, as well as the natural, sciences. The sole remaining question is whether the major decisions will be made by broadly trained resource managers or by professional administrators who direct a corps of resource technicians. This does not imply that the title technician is a pejorative one, but it does indicate that there are challenging opportunities for those who are willing and able to gain a more comprehensive perspective of resource problems.

Hale has recognized both this dilemma and this challenge. He has contributed several arguments for and method of broadening graduate conservation training in building programs such as that at the University of Michigan.[1]

The thesis of this paper differs from those views just reviewed in two fundamental ways. First, while fully accepting the argument that students of resources should receive more formal education in such fields as communication skills and social sciences, it adds that they should also receive more formal education in the resource fields other than their specialty. Second, while fully accepting the importance of aiding students of resources in broadening the base of their

[1]See "Broadening Graduate Conservation Training" by Roger D. Hale, pp. 459-470, Transactions of the Twenty-Seventh North American Wildlife and Natural Resources Conference.

specialties, it questions whether the only, or best, way to effect this is through graduate training.

The rationale for these related points can be summarized under four main headings: psychology of learning, resource ecology, administrative hierarchy, and nature of knowledge.

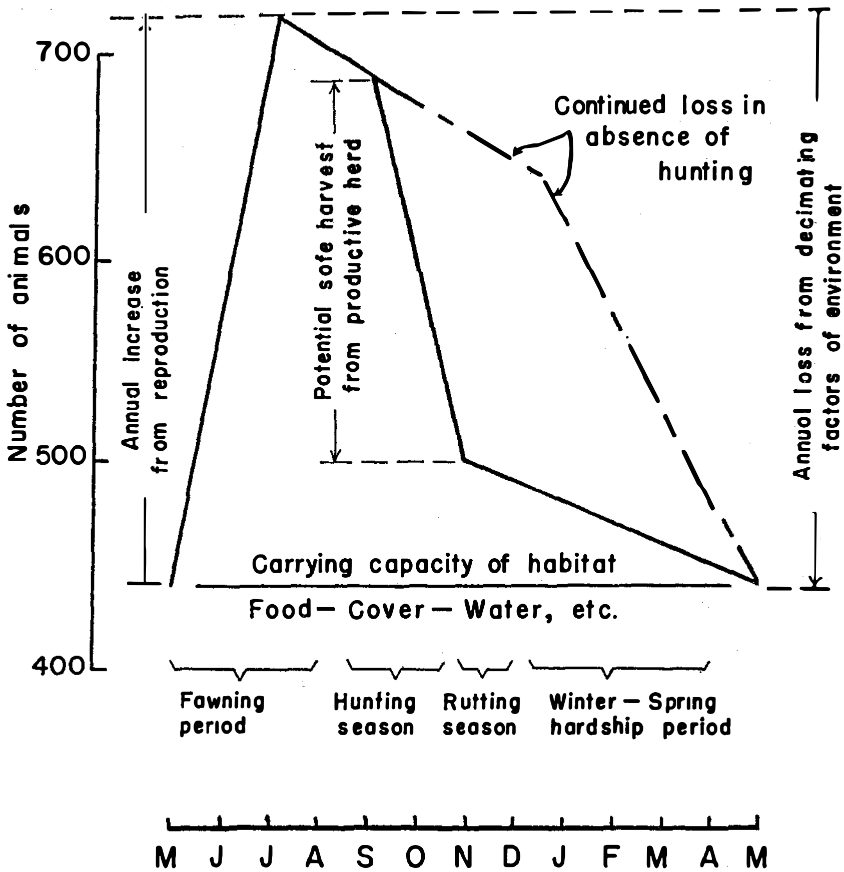
1) *psychology of learning*—

There is considerable, though by no means conclusive, evidence that learning principles and concepts as meaningful units which can then serve as a framework for associating and learning specific facts is a more effective learning procedure than the reverse. As the field of conservation matures, it seems reasonable to assume that continual refinement of the principles involved will justify further experimentation with this approach. Recently there has been considerable progress in developing a cadre of such principles useful to both the educator and the resource manager.

A simplified example of this is that a student does not have to be a specialist in any one phase of resource management in order to develop an understanding of sustained yield and the concomitant concepts of capital maintenance, allowable harvest, extinction threshold, biotic potential, and environmental resistances.

Figures 1 and 2 represent what might be referred to, respectively, as the specialist's and the generalist's approach to sustained yield. Figure 1, which many of you may recognize as being taken from Dasmann's lucid book, ***Environmental Conservation,*** is virtually self-explanatory and graphically illustrates the vicissitudes of a hypothetical deer herd. Figure 2, which my students refer to as "the abstract bullseye," is an attempt to illustrate some of the concepts applicable not only to deer, but to all flow resources which have a critical zone. Bearing in mind that radial distances represent population levels (number of deer, board feet of timber, etc.) and that the time continuum is represented by clockwise revolution, parts of Figure 2 may be "read" as follows: Starting at point A the population rises since the biotic potential is greater than the cumulative effect of environmental resistances. The maximum population attainable is represented by point B; the curve BD represents decline from this population level due to environmental resistances in excess of the biotic potential. Line BC represents an allowable harvest followed by gradual decline of the population to point D. The line EF represents an excessive harvest which reduces the population level to the (shaded) critical zone and results in eventual extirpation or extinction (point G).

This general conceptual framework can be treated at various levels of sophistication; for example, it accommodates refinements to include



Redrawn from Dasmann

Fig. 1. The annual fluctuation in deer population and the shootable surplus.

the operation of density independent and density dependent factors, it can be used to emphasize differences as well as similarities among the various flow resources, and it can serve as a starting point for analysis of the biological basis for legislation controlling harvest of flow resources.

Our experience with this and similar conceptual approaches to teaching resource generalists has convinced us that we are on solid psychological ground.

An additional psychological factor, not to be ignored, is that as a student matures and has had an introduction to a wide range of resource fields, he is more likely to make a judicious choice of the field in which he will eventually specialize. Similarly, his ability to select a significant problem for graduate study is likely to be enhanced.

2) *resource ecology*—

The fact that all resources, indeed all components of the ecosystem, are inexorably and intricately interrelated is commonly accepted by resource managers; but one does not have to read *Silent Spring* to know that in actual practice the implications of this knowledge are too frequently ignored. In short, too many of our resource personnel suffer from selective myopia; the fact that the environment is holocoenotic has not adequately influenced their management decisions.

Perhaps this is due in part to the fact that it has been " . . . possible for generations of students to take courses in ornithology, botany, mammalogy, ichthyology, entomology, etc. (which might cover the taxonomy, morphology, histology, embryology, or anatomy of any group), without learning anything of the relationship of species with each other, the competition between species, the effect of climatic variations on total populations of all life, of the dependence of all life upon soil and water, of the role that such biological communities play in soil building, soil protection, soil restoration, and water management and control." (Gabrielson, 1959).

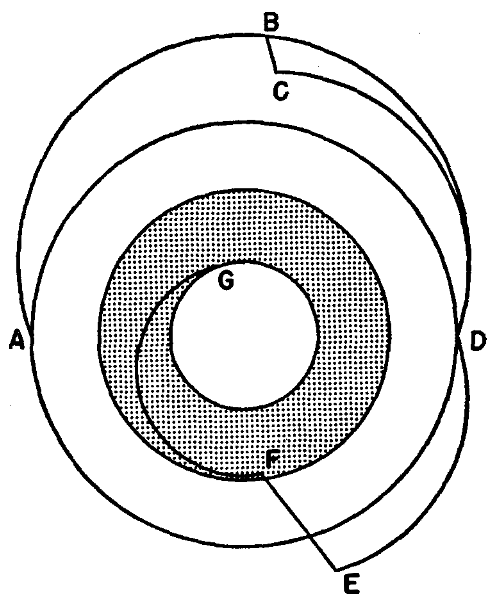


Fig. 2. The Nature of Flow Resources With a Critical Zone.

Sylvester broadened and strongly supported this view by stating that "a thorough understanding of all resources and of their interrelationships is prerequisite to the intelligent management of any single resource." (Sylvester, 1957).

3) *administrative hierarchy*—

The above argument is not limited, as some authors seem to imply, to the upper echelons of resource administrators; it is equally valid at the "firing line" level of those like game wardens and forest rangers and teachers who may never go on to graduate schools. Perhaps we need another Einstein who could develop a theory of resource relativity which would help all of us in understanding our environment—not merely in terms of events, but also in terms of relationships.

4) *nature of knowledge*—

Many facts and specific management techniques are ephemeral; whereas, implicit in the definition of principles is the idea that they are more enduring. If facts and techniques are antiquated more readily than principles, which logically should be learned earliest in the academic career? Which should be learned as close as possible to initial employment? Which can be learned most effectively as a part of on-the-job training?

Although these considerations seem to offer strong support for educating some resource generalists at the undergraduate level, such a plan has received more acceptance in theory than in practice. Among the reasons, if not the excuses, for this are that the men who have made the speeches about the values of the generalist have not given the same message to their personnel offices. They have, in many instances, continued to plead for generalists and hire specialists.

Another factor which has discriminated against resource generalist training at the undergraduate level is the vested interests of the older professions such as wildlife management and forestry. Even though members of these professions fought a similar battle for recognition not many years ago, some of the professionals in these fields view generalist training as a threat rather than both a compliment and a complement to their own work.

At last year's conference Alexander called attention to a related problem of these vested interests and presented more food for thought on the value of educating resource generalists by stating that "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." (Alexander, 1963).

A third factor has been lack of courage and conviction on the part of many colleges and universities. It unquestionably takes some soul searching before setting up a program which a) in some respects reverses the accepted methods of education, b) may have no students, 3) demands much of potential students for whom there may be no professional positions.

A final factor which has retarded undergraduate education of resource generalists has been the lack of understanding of the niche of such a student both by the student himself and by his (potential) employers. This situation has led to some noteworthy name calling and amusing anecdotes which may eventually create more understanding. For example, a graduate of our undergraduate conservation program at Wisconsin State College, Stevens Point, Wisconsin, should not be expected to compete with a graduate forester regarding root growth of hybrid aspen or with a graduate wildlife manager concerning what is known about the leucocytozoans in diving ducks. Unlike an acquaintance of mine with a Ph.D. in soils, however, our graduate would know what a watershed is. As a member of a research team in problems relating to wildlife, forestry, soil, or water resources, he could make a significant contribution—if he were hired. Too many of us tacitly accept the false dichotomy that a man's comprehension of natural resources may be broad or deep, but not both. We often compound this fallacy by showing a preference for the student whose training has not been broad; the assumption presumably being that it, therefore, must be deep.

There are some encouraging signs that the perspective of leaders in the various resource fields is broadening to the point where the niche of the generalist is becoming more apparent.

The Chief of the Forest Service stated last year, for example, "Our profession has demonstrated real leadership in wildfire prevention and control, in timber management, in reforestation, in research, and in many other areas. But we need to do equally well in the fight against poor land use, soil erosion, water losses and pollution, destruction of wildlife habitat, and similar problems that reduce the usefulness of forests and waters." (Cliff, 1963). Although there is, of course, no clear-cut line, it is interesting to note that most of the areas in which Mr. Cliff claims "real leadership" are distinctly the metier of the forester; whereas, those areas where much needs yet to be done apparently lend themselves to the team approach utilizing the skills of foresters, wildlife managers, soil scientists, hydrologists, *and* resource generalists.

With the current emphasis upon outdoor recreation and education, the potential role of the resource generalist, adumbrated by the early experience of the National Park Service, is becoming more obvious and more important.

A more basic omen that augurs well for the continuation and expansion of undergraduate resource generalist programs is the success of the students themselves. During the last two or three years there has been a significant increase in the number who have obtained professional positions in resource fields and in the number who have succesfully transferred to graduate schools for specialization in various fields of resource management. It is my belief that a sincere and thorough reappraisal of both Civil Service and graduate school requirements would not only add impetus to this trend, but also enhance the quality of our resource stewardship.

Among Fisher's points concerning "Resource Education for the Future" (1962), is listed, "It will emphasize the professional training of research specialists in the various relevant disciplines and resource fields without neglecting a more comprehensive view of the interrelation of all resources across the board." (Fisher, 1962). In short, specialists in the several fields of resource management will continue to fulfill a vital role in conservation, but there is a niche for the generalist, too.

In conclusion, I wish to reiterate some of the more salient points which have been discussed.

1) There is a continuous and growing need for resource generalists who have received rigorous academic training in the various resource and resource related fields.

2) The assumption that education of resource generalists can and should take place only at the graduate level warrants a skeptical reappraisal.

3) There are both empirical and theoretical grounds for advocating resource generalist education at the undergraduate level. These include:

   a) theory in the psychology of learning;
   b) the fundamental nature of resource interrelationships;
   c) the need for generalists at the lower as well as the higher echelons on resource management and education;
   d) the recent progress in the refinement of conservation principles and concepts which are conducive to resources generalist education.

4) Despite numerous impediments to the initiation and growth of undergraduate programs designed for the education of resource generalists at the undergraduate level, there is a definite recent trend toward their acceptance.

5) There will be a continuing and growing need for specialists in resource management; there is a niche for the generalist, too.

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DISCUSSION

MR. KEEFE: Thank you very much, Dr. Yambert. I thought that was an extremely interesting and challenging concept.

I am sure there are some comments on that, Bob?

MR. ROBERT L. DUNKESON (Missouri Conservation Commission, Columbia, Missouri): You say there is a growing need for generalists. I am not looking for a job, but I would like to know, is this growing need reflected in employment opportunities, or is this something that you see as a need of the profession?

DR. YAMBERT: I guess the answer is "both." We have been pleased, though, in the last two or three years in particular, that various groups—federal, state and private—have begun to recognize that people with this kind of training can be a valuable asset. Many of these have been in interpretive areas—the Park Service, private nature centers and things of this sort. We certainly don't think this is the end, but it is a strong beginning and, plotted on a graph, our employment in this area looks pretty good.

MR. KEEFE: I might comment on that, Bob, that most jobs in our line of work required advanced training, and Dr. Yambert says it is in the advanced training that they get the specialty out of the way. Is that right?

DR. YAMBERT: Yes.

MR. GEORGE WHITING (Washington, D. C.): I am afraid that we left the impression here a little earlier that the way to solve many of our problems is to study Madison Avenue methods, with the idea of using them, if we can.

Let's not forget that we are poor folks. We don't have that kind of budget. We don't have the multi-million-dollar budget of the American Tobacco Company or any of these others. So when we go home we will have to remember to tailor our approach to our resources.

The question I would like to ask is, what are we going to do if this forester or wildlife biologist or other person has not had generalist exposure but needs it now that he is on the ground? Frequently we run into the problem of getting our technical man interested in I. and E. He is interested, but he knows very little about it.

DR. YAMBERT: I think this is one of these cause and effect problems. I would like to argue that if my ideas were in force, you wouldn't have this problem. As it is, I am not arguing that all of the universities that have specialized training at the undergraduate level and offer generalist training at the graduate level should be torn down. I am arguing that there is a niche for the generalist who is trained the other way.

Such programs as that at Michigan, the University of Michigan, I think are filling at least in part the need that you mentioned, but our students don't have that problem because they have the general training before they go on to graduate school.

I am not sure this is the answer.

MR. WHITING: My question is, what do we do for this fellow? I am familiar with Michigan. I came out of that same school. But what do we do for the fellow? How do we give him a little help so that he can catch up now that he is out?

DR. KARL F. LAGLER (University of Michigan, Ann Arbor, Michigan): I was gratified, incidentally, that Yambert never mentioned fisheries. He must have seen me sitting here loaded for bear.

To answer your question, there is a solution, and that solution is simply to give the man who is in the position that you state some time to read and time to attend conferences like this; to get out of his state, most importantly. Let's see you cram that down the Commission's throats and win the point, and you will have it made.

MR. KEEFE: Also in answer to your question, the A.A.C.I., which is the Conservation Information group, will hold their meeting in Texas from June 14 to 17. Get some of your technicians down there.

DR. LAGLER: Yambert implied that the University of Michigan's educational program was a pyramid in reverse, and I don't think he really meant to do that. I haven't seen the diagram in his paper, but if I were to draw it from what he said and from what I believe, and perhaps probably many of you share, you would envision education of the professional in the conservation fields, whether or not he ends up as a generalist or as a technical specialist somewhere, he would envision his education, I think, as a pyramid, as many of us do, with a broad base in cultural subjects; perhaps then in some area with a second layer in this pyramid that is in biological sciences, with maybe then approaching a graduate layer of one kind for some field in aquatic biological science in my area; and finally, at the very pyramid, a man, say, working toward a doctral degree with real research potential, here finally specializing in fishery science at the top of this pyramid.

The goal is hard to attain, but the concept I think is one of long standing and is supported by Yambert's remarks.

MR. G. M. BRANDBORG (Montana): I think, in reply to the gentleman here who was concerned about manpower to put on what needs to be put on in this country, if we will think of the implications of proper land and water use, and the fact that it takes a rich land to maintain a democracy, and the fact that we need to just look about us to see what is happening in other countries of these achievements of productive land and productive water are not maintained, and I think the fault lies in this. I sensed it yesterday in the Extension meeting that I attended. There was an apology for asking for money for these kinds of things.

My God, men, all you need to do is create a concept of what you are trying to do and you will get the money. You will get more money, maybe, than the researchers are getting. It is no use of applying the findings; we can't apply now many of the findings of research, and as you make those facts known I think you will be getting as much money for the cause of conservation education and promoting your ideals and ideas as the researchers are getting.

It is a matter of selling your wares on the basis of the principles of proper land use and proper water use.

MR. LARRY JAHN (Wildlife Management Institute): I, too, was in the Extension group yesterday, and I am curious about this training of the generalist. You mentioned that in effect we have an existing volume of knowledge which in effect we want to see applied to land and water. This is fine, but in the training of this generalist are we giving him training in urban and rural planning, in the structure of county government, in dealing in a political environment? Do you consider this part of the training of the generalist as an undergraduate?

DR. YAMBERT: There is no question about it.

MR. JAHN: Hopefully you do, because at the present time there are many job openings for people who have backgrounds in fish, wildlife, and other resources, but when it comes down to having mentioned, the people with a real feeling for resources lack this basic training.

MR. ROBERT BURNAP (National Educational TV, New York): I am with the National Educational Television network. We are in the process of researching, planning and designing a series of twelve one-hour films to be broadcast monthly starting in the Fall of 1965, and the topic that we are dealing with relates to this morning's program. We have gotten many excellent suggestions from the speakers this morning. The subject is *The Environmental Revolution: Man's Impact On and His Relationship to His Environment* throughout history but particularly since he has acquired enormous technological powers.

Our goal is to turn to the general public, since the listening public is National Educational Television, which includes now eighty stations and we hope by the time we go on the air it will be 120 stations, interesting what we will be able to say are the generalists, those who can understand the basic concepts behind resource management and the management of our resources generally in the natural environment. We want to show the connection between men and their resources, their dependence upon them, and the consequences of their actions.

We want to, as has been suggested, delve into the political, sociological and psychological aspects of this. We want to make it a two-way communication. We wish to make it into a dialogue between the stations, the local stations, and the communities, through the use of study guides and other materials.

I have here a suggested outline of some of the questions that we are raising. I am going to leave it on a hall table. If anyone would like to pick one up we would be happy to have him do so. We are looking for suggestions and ideas and will appreciate the help of anyone who wishes to contribute.

CONSERVATION'S MYOPIA

ROBERT D. CALKINS
Deputy Director of Conservation, Sacramento, California

Historically, North Americans have considered their continent as a cornucopia of plenty with an unlimited supply of all the basic natural resources upon which man depends.

Today those who would project our present extravagant wasteful practices in the use of these resources simply point to the way we have used them with ingenuity, ambition and untiring effort to produce the most affluent economy in history. The system is working fine. Why not continue a good thing without change?

The conservationists and resource professionals at this North American Wildlife and Natural Resources Conference are trying to provide the answers to that question. The answers must be positive proposed solutions to wise and continuing resource use. There must be answers which can be transmitted to and understood by all segments of this continent's population. Once the people understand what is happening to their basic natural resources and how most of them could be managed and used forever, the democratic form of government will bring about the practical solutions.

The danger flags started flying over various natural resources more than 50 years ago. The people saw and heard things they didn't like. These signals generated a new philosophy, now commonly termed conservation. Probably the most practical definition of the term so far developed centers around wise use for the benefit of the most people for the longest period of time.

Around this conservation banner, during the past 50 years, have marshalled a variety of natural resources expertise, botanists, foresters, fish and game biologists, entomologists, geologists, sanitation, water and soil engineers and information-education sociologists, but to name a few.

Generally speaking, each speciality undertook to find facts which would solve specific conservation problems relating to the resource of its concern. In most cases the efforts were defensive or protective ones to halt running destruction, and secondarily to provide constructive proposals for the future long-range management and wise use of the resource. Even with the handicap of starting from behind, the conservation-minded resource experts made reasonably good progress in halting or slowing down the worst villains in resource destruction—reasonable in terms of needs and conditions prior to World War II.

But what was reasonable progress between 1900 and 1950, accomplished through the myoptic practice of "each expert to his own, and the others can comment later," today means regression in over-all conservation progress.

The social and economic revolution in which America and the rest of the world finds itself today is transforming demands on basic natural resources which pose completely new challenges to the resource technician and administrator.

Governor George D. Clyde of Utah recently told the National Association of Manufacturers that the most pressing problem in the United States today is the problem of conserving its natural resources. Governor Clyde contended that the critical point has been reached in matching the available natural resources with the projected population. Conservatively, he said, this nation's population will double every 37 years. There are other authorities who place the doubling figure at 20 years on a geometric pattern.

Coupled with that are such predications as that by Vincent Bousquet, director of the Western Forestry and Conservation Association, that industrial production in this country may double in the next ten to twelve years.

Enlightened recognition by the economic users of natural resources is creating a mounting ground-swell within the industrial and other economic segments of the economy which is moving with conservation's wise use principles.

The National Association of Manufacturers, at their first Conservation Conference in San Francisco, presented a day-long program discussing a variety of problems as well as accomplishments by industry in the natural resources conservation field. Many of the speakers had the same philosophies on conservation as do the members of this conference and could prove it with accomplishments and programs of their enterprises.

Similarly, recent representative conferences of farmers, cattlemen, sheepmen, loggers, timber operators, and private interest water developers reflect in their deliberations increasing activities and productive effort along the same road which the professional conservation expert would have them go. They are spending increasing sums of money to put resource experts on their staffs to develop better methods for resource conservation.

Interestingly enough, they talk at their conferences largely to themselves, too.

To meet the challenges of accelerating human needs, producers of natural resource based products are recognizing, more and more, that their future prosperity depends on following the principles of wise use.

Unfortunately, the leaders of the conservation movement are not inviting the leaders of the industrial conservationists into the conservation family. Each group continues to travel its historic myoptic way.

The sociologist, principally through government, also is entering into the arena of concern for the future of natural resources.

Anthony J. Celebrezze, Secretary of Health, Education and Welfare, recently stated: "My experience has convinced me that we must increasingly think of our urban environment, and deal with it, as a whole—as a single unit with closely interrelated and interdependent parts. In our modern cities we cannot separate housing from health, or either from transportation, or any of these from the resources of our natural environment, such as air and water."

Here we have the sociologist stating the only way to deal effectively with human resources in cities is to look at the "Big Picture" and deal with it in relation to how various factors within the picture affect each other.

The conservationist and the resource developer and user might well consider whether he is looking at the whole natural resources environment as a single unit of closely interrelated and interdependent parts.

It is unfortunate that the record of the conservationist shows that his concern with a given resource outside his specialized interest seldom is brought into consideration unless it happens to be one which impinges on his interest. He has worked on little parts of the big picture very effectively. This is the easiest way to get a name on a professional paper, to become an expert in a specialized field. Such specialists are essential to provide the basic facts on each part of the "Big Picture." These are the beneficial results of those who 50 years ago dreamed and did something about conservation of the future of America's natural resources. But the methods used in the past won't meet the challenges of the future.

There are, however, many gratifying victories as well as straws in the wind pointing to more successes in the future. Statutes on the books are being implemented and expedited. Some coordinated long range resource planning programs at both state and national level, are making real progress. Now let's consider how this progress might be increased.

The decision maker—that is the administrator, the executive and the legislator—is not being given the perspective of the "Big Picture" along with a variety of possible solutions for problems within that resource picture by the resource expert. And almost never is the decision maker given an evaluation of the adverse effects the expert's recommendations would have on other resources.

Consider a few of the major considerations before Congress today—wilderness, regional water development, use and disposal of public lands, recreation, and preservation, among other economic and sociological questions. On what kind of testimony and expert advice are congressmen going to depend for arriving at decisions on these natural resource questions? The answer is that most of the information and pressure is unilaterally produced by single entities having strong interests. Much of it is prepared by highly competent professionals—in their particular fields.

What is sorely needed for logical solution to these complicated questions is a selection of acceptable alternatives worked out collectively among all the interests concerned.

If the day ever arrives when resource professionals, business interests, recreation and aesthetic value enthusiasts sit down and cooperatively work out alternate recommendations on natural resources from which the decision makers can make a choice, the future of this continent's natural resources will be much brighter than it is today. That would be "the Good Life."

Unfortunately, such cooperation as exists today is usually at arms' length and only invited by the resource interest which decides "cooperation" from the others is essential to success, and given only if "cooperation" won't hurt the "cooperator's" interest.

Utopia can't be accomplished where myopia exists.

There is an especially important role which the information-education specialist could play in bringing about the "Good Life" if he is willing, and perhaps more important, given the opportunity and direction to do so. Again, unfortunately, too many conservation information-education specialists, in both governmental agencies and among business and citizens organizations, are occupied in one of two job classifications—fire fighter or single product salesmanship—and other duties as required.

Their bosses might well take a new look at how they're using this expertise. Accurate information, particularly if it has broad significance and perspective, is an invaluable resource in itself.

The military organizations of nations throughout the world have long recognized this basic fact and consider essential to their success staffs of people who collect, summarize, compare, interpret, give perspective to, and often make recommendations for decisions and actions.

Unfortunately, conservation interests generally have not recognized nor have used the basic principles of intelligence, evaluation and use. Most struggle to throw out a few facts to their clientele to put out that little fire or to sell that little piece of merchandise. To the military organization, proper collection, evaluation and use of information is a matter of life and death.

To the natural resource user in North America—and this means every human being—the future availability of natural resources is not a matter of life and death as it is on most other continents of the world. It's not a matter of life and death here—yet, but in 50 years, it might well be!

DISCUSSION

MR. O. M. SIZER (Arizona Game and Fish Commission, Clifton, Arizona): This is not necessarily a comment on this particular speech, but it is one which I think is pertinent.

In my own effort I sometimes try to sit down and evaluate my own self to discover my weaknesses and then take measures to overcome them. However, there are times when I find that this might be difficult, and I just realized that last night after attending one of the girlie shows.

But to put this in pratice, I think it could also be done with organizations, and I think one of the weaknesses in our departments is the fact that we do not spend enough time and effort to shuttle our own programs to our own personnel. I think this is most important, because if the man in the field, who is your greatest ambassador, who deals with the public, is not sold, then you had better take a good look at your program.

I just thought I would throw that in because it is one I believe that we are very lax in.

MR. KEEFE: Thank you, sir. That is a very good point.

MR. WILL BIOFF (Sequoia National Park, California): Mr. Calkins I think endorses the statement that the Governor from Utah stated to a conference that we attended recently, where he stated that the biggest problem that we face in natural resources today is matching the people to the resources and matching the resources to the needs of the people.

That has long been considered by many people to be the real need we probably face. But if you endorse that idea, then you are engaged constantly in compromise. When there is any conflict coming up on natural resources you get together, if you do as you recommended there, and you decide that you are going to get together with these other conflicting interests, and decide how to split this pie.

After you have given away a little bit, after you have made compromises, then along comes the next problem and you split the pie again. In the end, unless you have solved the basic controversy, which is in my opinion the human population explosion, you are going to split this pie to a place where there is no longer anything for anyone. So the specialist oftentimes is accused of being narrow minded because he knows that this particular resource that he is interested in is going to split and resplit and resplit, and if you go to the conference table this time and you agree you will divide it this way, you know that just in the offing there is another claim going to be made or use going to be made of that resource, and you are going to have to split it again, and you are going to end up with nothing.

I have talked too long, but I think the basic problem is the human problem, and not how you split this resource. You can split it only so far. We can manage it better, but there is only so much to be milked out of it.

MR. CALKINS: The idea I am trying to get across is this. I can't deny your point of view here. On the other hand, today, right now, and tomorrow, and for the next ten years, our environment is going to be changed. What I am saying is that it is time right now for the experts in the fields of all these resources to take a look at the big picture and perhaps come up now with what kind of a land do we want here as a final picture?

We haven't asked ourselves this question. We have a little argument about withdrawal, or water development. But all of the experts in that field whose resources are going to be affected one way or the other have never sat down yet and, before they started planning, decided on where they were going.

CHAIRMAN RETTIE: My question takes the form of an elaboration on a comment that was just made by a previous questioner. I make this in the form of a question, and I suppose this reflects my own point of view as well.

If population—people—is basically at the root of what will be the national natural resource and conservation problems of the present and the foreseeable future, I can only ask this question: How can conservationists and conservation technicians, and conservation information and education specialists, continue to ignore the basic population problem, instead of relegating the problem soley to the province of the demographers and the social scientists?

MR. CALKINS: Well, I don't think they can. I think it is a part of the consideration that resource people have to make in relation to how you are going to use the resources—your lands, your water, and so on. You have got to take that into consideration sooner or later.

DR. WENDELL SWANK (Arizona): I would like to speak of that a moment.

It seems to me that we as natural resource managers must get into Chambers of Commerce and work with our people who are emphasizing more development and more people rather than emphasizing quality and use by the people we have here now.

A couple of weeks ago I attended a conference up in Northern California and they were talking primarily about diverting the Klamath River. And one fellow got up and said, "What in hell is the use to build an affluent society if we are not going to have anything to enjoy when we build it?"

I am from Arizona, and I know that today my Governor is traveling all over the United States extolling the virtues of coming to Arizona, and all he is doing is splitting the pie among the few we have there now.

We are not going to get the job done unless we employ quality, and let's enjoy what we have here now by the people we have here now, instead of trying to bring more in and build more dollars upon the stack we have now.

MR. KEEFE: This is almost heresy, sir. In America the only way we progress is to get bigger.

DR. WILLIAM J. HARGIS, JR. (Virginia Institute of Marine Science, Gloucester Point, Virginia): This point that has been raised has come up before, this business of human population control. Unfortunately it is at the root of the problem. And just as unfortunately it is a complex problem.

We haven't solved the simpler ones yet. This is not to discourage attempts at solution of human population increases, but it is to say that we are a part of a fairly large mechanism, a mechanism for conservation, and that while we recognize and should acknowledge and we as conservationists should urge a quick and reasonable approach to the solution of the human population problem, one of which seems to me to be to maintain or help in maintaining political stability so that this complex problem can be solved.

Complex problems can't be solved in a chaotic condition. We are not solving the population problem right now in our own country, which is one of the most sophisticated on earth, and best educated. So that I would say, criticize the conservationist for perhaps being myopic and not working more actively on human population problems, but acknowledge the difficulty and complexity of the problem and build on top of the system a group of experts, a group of technicians that will solve or will work on this aspect. We can't do it all.

There are a couple of other points, and this is sometimes an excuse for interjecting your own opinions into a situation. I would like to urge, in the development of a broad approach, of a generalization, Dean Yambert, that you include marine resources. These are complex resources and a coming problem, and one finds it extremely difficult, as a marine conservationist, to find which conservation organization he should become part of, an active part of. In your plea for generalization, for general training, I would like to comment, as Dean of a school of marine science and also as an employer of marine scientists, that we prefer to have people come to us with broad training in biology if they are going into biological oceanography or marine biology; in chemistry if they are going into chemical oceanography, and good training in the humanities, with chemistry, history, mathematics and physics as much as possible, and to train them in the specialty after they get to us.

Unfortunately many of the wildlife and fisheries departments in the universities start out too soon training specialists, and quite unfortunatly it is this youngster who suffers from this early specialization. He finds after a while that he would like to go into something else and he can not, because he is hung.

MR. DAVID BROWER (Sierra Club, San Francisco, California): Borrowing the statistics from Bob Bernap, who spoke briefly a while ago from N.E.T., it took all the time from the first man's arrival on earth to the year 1650, about a million years or so, to produce the first half billion people. It was when the population got to a half billion. And we did it again in the last ten years, so that we are going at a rather rapid rate. I never saw the figure put that well before.

In any event, our audience in the I. and E. work we are going to do is thus expanding much faster than any program we can imagine to reach it. I think we are in trouble if our stories keep predicting this unmitigated growth of people, instead of suggesting that there is a much more sensible conservation ethic than that unmitigated growth. I am not despondent at all about it. Ten years ago you would hardly see it touched upon at all, but in the last ten years I have seen it come up oftener and oftener, and now lou hardly find a newspaper that does not touch upon it.

You don't need to go into a lot of mechanics. I am not worried about that. Change the ethic and the population can stabilize. This has happened in Japan; it happened in this country during the depression. It happened in Europe. It was going the other way in Europe before World War II. You change the ethic. I. and E. people can do it. Conservation I. and E. people had dammed well better.

CONSERVATION EDUCATION—A NATIONAL FAILURE

R. G. LYNCH
Former Natural Resources Writer for The Milwaukee Journal
Wauwatosa, Wisconsin

When, as a veteran newspaperman, I was assigned to natural resources, I had a field day and enjoyed it immensely. Other papers had outdoor and farm editors but nobody else covered the whole, broad field.

I did a lot of reading to get needed background. One fruitful source was the transactions of a symposium held in the mid-'50's on Man's Role in Changing the Face of the Earth. Summarizing that week of discussion, Dr. George Sauer, University of California geographer, said:

"Thus we are brought to a revised version of Aldous Huxley's 'brave new world' of the '20's—to a faceless, mindless, countless multitude, managed from the cradle to the grave by a brilliant elite of madmen obsessed with technological progress."

This comment came to mind again and again as I observed and wrote about conservation affairs. Meetings like the North American, the watershed congress, the Wildlife Federation, the Soil Conservation Society and others had a sameness—the interested few gathering to tell each other more about what they already knew, and spreading very small ripples indeed among the public.

After a few years I began to feel frustrated, even a bit angry. I saw things that I covered for the Milwaukee *Journal* practically ignored by many newspapers. And even though the *Journal* had a half-century tradition of conservation coverage and I had the chief editors' backing and old friends among the desk editors, there were problems of getting space and position in the newspaper. Also, in the conservation field very little seemed to happen; the story needed to be told over and over, and a retold story is not news.

I began to feel kinship and sympathy with sincere and dedicated men in resource work, to see that they often were frustrated or re-signed. Eventually I realized that our difficulties were the result of a national failure in conservation education.

This is a failure for which you and everyone in this work must share the blame, because you are the ones who know the score. Sure, you carry on research and action programs, provide publications, work with schools and clubs; there is a wildlife week and soil stewardship.

These are all good things in varying degrees, but here the guiding principle of Ignatius seems pertinent: "There are many goods, but time is short; concentrate on the greater good."

The conservation movement, I think, has not done this. It has many branches but their fruitfulness is severely curtailed for lack of roots.

Von Humboldt said: "Whatever we wish to see introduced into the life of a nation must be first introduced into its schools."

That is our difficulty. Conservation never has been introduced into our schools. Everyone in the natural resources fields should be pressing aggressively to get some effective teaching of conservation in all schools from the elementary level to the universities. You not only know the score; you have a personal stake: your income, your status and what you will be able to accomplish depend on the awareness and interest of the people.

Before I go on I had better define what I mean by conservation education.

Conservation has been used to fit so many meanings that it is no longer a working word. To me conservation is simply frugality. Of course, any word may be misunderstood. There's a story about a little girl who was given the word, frugal, to use in a school composition. She looked in the dictionary and read, among other things, that it meant to save. Next day, called upon in class, she read this composition:

"Once upon a time a princess went horseback riding. When her horse jumped over a creek, she fell into the water. Just then a prince came along on his horse and she called to him, 'Frugal me! Frugal me!' And he got down and frugaled her and they lived happily ever after."

As for education, too many people think it is merely the gaining of knowledge. There also must be understanding and in some things, like resource conservation, there must be motivation.

So conservation education must be the teaching of a basic truth, that we have to be frugal with our resources so that they will remain fully useful for us and for our descendants.

This seems like a simple thing, but it is not. It is extremely difficult in a nation that has abandoned frugality as a way of life, whose people are obsessed with the desire to satisfy immediate wants, dedicated to installment plan living and concerned about the future only for financial security.

There is not time to discuss conservation education nationally. As an indication, I will tell you that Wisconsin since the 1930's has required conservation teaching in the schools and training of teachers to do it; since '53 has made state school aids contingent on such teaching. State committees have worked on it; there has been an organized summer workshop program for teachers and student teachers, carrying credits.

Yet, good sampling surveys in 1950 and 1957 showed very disappointing results. In 1957, 42 percent of the elementary schools sampled did not respond and 10 percent of those that did were not teaching conservation. Many of those professing to teach it undoubtedly had little more than a label to comply with the law.

Wisconsin is only one state, but it has been a pioneer in conservation education and a national leader in resource legislation and programs. In my opinion, the status of conservation education is worse in most of the other states, where it has any status at all.

Oh, it has been gathering momentum in the last decade or so. There are teaching materials now, some good, and teaching methods. But the basic problem remains: the teachers' attitude.

Teachers of today and young people preparing to teach were given much the same kind of schooling that most of us got. I never heard anything about natural resources or conservation in school and neither did my son. I think that most of you would say the same. Teachers expect to teach the things that they were taught, and conservation is not included. I think you know that teachers shun anything unfamiliar.

Generally, where conservation is taught it is integrated in regular courses. That is Wisocnsin's method. A few years ago, while preparing a series about conservation education, I learned that history teachers had tried to get themselves relieved of conservation teaching—it did not "belong" in a history course!

How could anyone teach history without dealing with the use, abuse and competition for natural resources that has gone on as far back as we know what happened on this earth?

I found a lively feud between biologists and geographers as to which should teach conservation in the teachers colleges. A recent book offered as a text emphasizes the economic value of natural resources. I know that ecology must be the basis of resource management but I have come to the point where I don't care what the approach to conservation teaching is, as long as the message is there. We need it so desperately that it must be acceptable in any form that will be effective.

The failure extends from bottom to top. Our colleges are turning out lopsided minds—men highly educated in specialties but woefully ignorant of many things, particularly the need to live within our resources.

From a population that schools and colleges have failed to interest in resource conservation, we get our lawmakers as well as our teachers—and we also get our newspapermen.

The newspaper is the most important medium of education for people after they leave school, so the newspaper has a function and a duty to inform about resource matters. Many fail to perform this function; some do not recognize the responsibility. This is due in large measure to the failure of conservation education in the schools.

Conservation matters must become news before anything will happen. Information and Education programs arose from realization of this fact. I&E is a euphemism for press relations, which would never get by in public budgeting. I&E people provide a good deal of useful information and in some cases make educational gestures, but these are pitiful when compared with the need.

I&E men are licked before they start. Licked because it is not possible to inform or educate people who are not interested or even aware of resource problems.

I wonder how many of you understand the dimensions of this national failure. Not many, I think, or you would have done something about it long ago, instead of leaving it to school men, most of whom actually resist changes in the old routine.

Let me put some pieces together and see if they make the same depressing picture for you that they do for me:

One of my first North American conferences was in St. Louis. That city has good newspapers, one that ranks among the top five in the country. They hardly mentioned the conference. I must say that the North American is easy for a reporter to cover, for Dan Poole runs a good press room. So the absence of stories in the St. Louis papers had to be due to a lack of interest by their editors.

The same thing has happened in other cities in varying degrees and with various resource meetings.

Last year at Detroit a feature of the conference was the Leopold advisory board's report on the national parks. The board went far beyond its assignment and commented critically on the whole program and the very philosophy of the park service. This was NEWS.

But one Detroit paper carried no story at all and the other reported only about hunting in the parks. The United Press International carried part of that story on its regional wire; the Associated Press put out no story. Nationally, there was nothing about this report until the Interior Department, weeks later, put out a release in Washington. Then it was old for newspapers. Most of the national reporting was in conservation magazines and bulletins.

More recently, after we suddenly and sadly had a new president, stories came out of Washington examining Lyndon Johnson's background and probable attitude on everything from foreign affairs to civil rights, welfare, education, crop supports and the tax cut. This was before I left my paper, so I watched for something about the new President's probable attitude in resource matters. Nothing came—not a line. I finally put in some calls and got a story for the *Journal*.

Washington press men certainly are aware of resource issues but it seems obvious that they do not consider them very important. Perhaps the writers assigned to assess the new President, or their editors, did not even think of examining Mr. Johnson's record in resource matters.

I could cite more such incidents but the point has been made. On the news totem pole, if conservation has a place at all it is at the bottom.

Newspaper space is extremely tight and competition for it is brutal. When I broke into the business nearly a half-century ago, my editor's horizon was about the state line, occasionally flicking into national affairs and rarely to the world beyond. A couple of telegraphers took all of the wire copy when I joined the *Journal* staff 42 years ago.

Now the Journal has five wire services and 16 teletype machines. The mail brings additional copy and reporters turn out more. The editorial rooms are full of large waste baskets and they overflow. The editor's horizon reaches to the moon.

Men on the nation's newspapers who must chose from this torrent of material are in a squeeze. They haven't space for even the stories they hopefully select. A lot of type goes into the hell box and cost experts shriek about the waste. A story often runs in one edition only, then is killed to make room for something else, enabling the decision maker to salve his conscience.

In this squeeze, many editors do not give even a passing thought to resource matters unless they are within the circulation area or are national storm centers. Even editors who are aware of conservation's importance know that their readers are more interested in crime, sex, politics, cold war, space travel and amusements. They know, too, that they must print stories that will sell papers. It takes a lot of money to keep a newspaper going these days.

It is time you people began screaming about this whole situation. Who is going to do it of you don't? Scream for conservation teaching in the schools and the colleges. Enlist the active support of newspaper editors, not just to print conservation articles but to hire men informed about resources and to demand such training in journalism schools.

If these things are not done, you will continue to butt your heads into a big, soft featherbed. You won't get hurt, but you won't get anywhere, either, not fast enough.

I said that all of you in the resources fields had a personal stake of pay, prestige and accomplishment. But we all know that the nation's stake is infinitely greater. It is more than resources.

A Yale philosopher, Filmer Northrop, once suggested that our resource problem is essentially that of a technological civilization which to a great extent has abandoned the values of a non-technological society and must recover them—esthetic, ethical and legal standards, emotive relationship to nature, and moral standards for determining whether man will use his tools for good or for bad ends.

"The last factor," he said, "suggests that the answer which the evidence and its analysis permit us to give to this question may well determine whether man remains the master or becomes the slave, and perhaps even the murdered victim, of his tools."

In closing, I say again that there is an urgent need for united action by all conservation organizations. Perhaps they could join in a conservation education year as the start of a continuing, unremitting effort to expand the three R's to four:

Reading, 'Riting, 'Rithmetic—and Resources!

DISCUSSION

MR. KEEFE: Well, I thought he was rather impartial in handing out the brickbats.

MR. BROWER: First, I have a question but a comment to precede it.

Don't underestimate what a book can do. I think all of us are well aware of what Rachel Carson did with the chemical industry. In our own limited way in the Sierra Club we have found books are rather helpful. Some of them are rather expensive. They do pay their own way. What they do is take the message we are trying to get out, whether it is fire fighting or something relating to long-range perspectives. They get it to the audience and the audience pays the price.

Beyond that we have found we have got very good review and editorial coverage on some of these books. I think *Silent Spring* had a great deal of its impetus from one of the men we see here very often. Clarence Cottam I think had a great deal to do with encouraging Rachel Carson. She should be encouraged. A book is a tangible thing, It isn't an image that hits you on the screen and then is gone. It doesn't go into the wastebasket so soon. It has an additional status.

My question, Mr. Lynch: Are you working on a book on the subject you discussed today?

MR. LYNCH: No, I am not.

MR. BROWER: I wish you were.

MR. LYNCH: I haven't found myself yet from my retirement.

MR. DICK RHODES (Forest Service, Pennsylvania): Russ's statement about the conservation stories ending up on the back pages and so on, which I have heard him say more wrathfully than he has said it today, reminded me that there might be a lot of people in the room here whose papers did not carry a story, or they haven't had word, of an important step in conservation sducation that was taken last September, when President Kennedy dedicated the Pinchot Institute for Conservation Studies at Milford, Pennsylvania. Earlier the Forest Service, by donation, had acquired the ancestral gray-towered home of Gifford Pinchot, and through the cooperation and help of the Conservation Foundation the Pinchot Institute for Conservation Studies has had its meager—to date—but we hope great future in this field of conservation studies, conservation education.

What the program will provide is an opportunity to overcome some of the myopia and some of the difficulties of educators and resource people working together. We will deal with and hope that it will attract people there to the fine library that it already has, and it will get better, of course, to study and work on such things as curriculum, programs, but it will be an area where resource people and educators can work together. We are pretty enthusiastic about it.

It is not a Forest Service program. It is a national program aimed at conservation education, and I hope that the time will come for us when the editors won't be able to keep it out in any part of the country.

Thank you.

MR. WILFORD OWEN WOODRUFF (Nevada): I am the father of twelve children. I have just been told that survival depends on conservation of natural resources, and I believe it.

I am a candidate for the United States Senate this year. I was with Gifford Pinchot in the company of Franklin D. Roosevelt in June 14, 1933, and I am thrilled with what I have heard here today. I am a former newspaper half owner; that is, I owned a newspaper in partnership, a very small sheet, and I am active politically. I would like to do a Huey Long with some of our present officers in Congress and in the Senate and ask them some pertinent questions about why we aren't doing this job. I would like to ask our school people why, and I am asking for your cooperation, because the gentleman like the one who just talked have information that is of terrific value, and we must get it out. I want to help.

I hope to meet him afterward and to have help from any of you who can give us ammunition to fire.

MR. KEEFE: Thank you, sir. As a candidate, it shouldn't be too hard to get your name.

MR. WOODRUFF: I would prefer not to mention it here because I am under Civil Service and this is not political yet.

MR. KEEFE: Sir, we need it for the transactions.

MR. WOODRUFF: Well, I can have my leg twisted, I assure you.

MR. GEORGE WHITING (Washington, D. C.): I notice that Messrs. Lynch, Yambert, Calkins, and in general the last three or four speakers, brought out this problem of educating our educators, and also this problem of educating our professionals into beaming them into a more general scope, but no one has yet said how we are going to do this and I would like to direct my question to Dr. Yambert before we quit here.

What approach can we take toward getting a broadened curriculum for specialists and various people in conservation? What can we do toward educating our educators who teach our teachers in this field? If we aren't doing anything right now, what should we do and how can we do it?

DR. YAMBERT: That reminds me of two things. One is a favorite test question which says, "Define the universe in ten words or less and give three examples." The other one is a quote that I heard from another oceanographer, who said, "To every complex problem there is a simple solution: simple, straightforward, and false." [Laughter]

So I don't claim to have any panaceas here, but I feel that there is a certain amount of truth in the analogy that we can draw from other fields of knowledge, that as disciplines or fields of knowledge mature, there tends to be developed a cadre of principles and concepts which are not only applicable but broadly accepted and true within the limitations of their definition, and to me the great hope is that we will be able to refine such concepts so that we are talking about the same things when we say "sustained yield" and the same things when we say "conservation." This "greatest good for the greatest number for the longest period of time" thing will be recognized as internally inconsistent because the philosophers and others will help us analyze this.

It may be a long-term pull, but I would like to see reorganization of our texts and reorganization of our thinking. We are very fuzzy. We don't define "resource" in the same way. We don't talk about conservation dealing with resistances as well as resources. So my feeling is that we need a thorough re-working of the conceptional framework in this field before we can go to the step about which you are talking.

DR. DANIEL LEEDY (Bureau of Outdoor Recreation, Silver Spring, Maryland): I have been associated with training of conservation people since before the War, along the Biological Science area, and I would like to point out that the matter being discussed here hasn't been entirely overlooked. Recently a book came out by Dean Emeritus Dana of the University of Michigan as one of the authors on education in the forestry field. A committee of the Wildlife Society is looking into this matter of professional standards and the hard core of courses to be taken by people in that field, and the Bureau of Outdoor Recreation and the State University College of Forestry at Syracuse are co-sponsoring a national Conference on Professional Education for Outdoor Recreation next July 9 to 11 at Syracuse, and they are going to be considering many of these questions and problems that have been discussed here.

MR. KEEFE: Thank you, sir.

I believe there is no simple answer, as Dr. Yambert said, but there are people at work and there is a ferment toward this solution.

MR. CARL LUNDBERG (Oregon): I do not have a question as much as a comment. It happens in our state, through no particular plan or certainly no systematic or formal approach, that practically every newspaper of any importance—and I mean the dailies, the important papers throughout the state—has at least one member of its staff, and quite often a top member of the staff, an editorial writer, active in conservation affairs. How that has happened is pretty much accidental, but they have been drawn into conservation activities through participation in the local woldlife clubs of various kinds, the Izaak Walton Leagues, Chamber of Commerce Committees on Recreation, and so forth.

They write editorials that are favorable; they see that the news is fairly well covered. Not everyone will agree with the extent by any manner of means, but nevertheless there is an interest in the conservation problems that is of distinct value.

I suggest that this is a form of development of understanding. It wouldn't be formal education, but it is actually what you are hoping to get through formal education, but is sometimes neglected. I admit that in instances the local club has done this with some thought of the benefits to be accrued. Certainly the awards that have been given by the Izaak Walton League and the Wildlife Federation and various local groups to newspaper men who have shown notable interest in and made notable contributions to conservation have contributed. It improves an expression of the attitude and understanding of conservation problems.

I say I am offering that as a type of informal and very effective education.

MR. KEEFE: Thank you, sir.

Mr. Lynch, do you have a comment?

MR. LYNCH: I will tell the man from Oregon something that might interest him.

I went to a meeting up in the Grand Tetons at Jackson Park Lodge. It was the Inter-Agency Committee on the Columbia Basin. It had been called so that the top talent from four federal agencies could explain the bill backed by President Kennedy to the River Basin Committees.

I would like to tell you that there was nobody from a Washington or Oregon newspaper at that meeting. So apparently they don't get around quite as much as they ought to, because that certainly was important to the States of Washington and Oregon.

MR. RUPERT CUTLER (National Wildlife Magazine): Russ, you have probably heard my associate, Dick Kirkpatrick, expound on his three-part slogan for National Wildlife. It rather shocked me as one who has come up through the ranks of state I. and E. organizations, where we tend to take ourselves very seriously and write pretty deadly dull material. Dick's slogan is that first you have got to attract them. You have to have pretty pictures. Second, you entertain them. You talk about travel or natural history or hunting and fishing. Then, when you have them reading your book, you educate them.

This may be a little hereticial, but conservation to the general public is a pretty deadly dull subject, and we have to package it a little better. Dave Brower, with his Sierra Club books, is doing it. We are trying to do it. I think it might be something worth thinking about.

MR. DANIEL SAULTS (Missouri Conservation Commission, Jefferson City, Missouri): With regard to a statement by Rupert Cutler, there are no dull subjects. There are only dull people thinking or writing about them. [Laughter and applause]

MR. KEEFE: I thank you all for being here. I hope we have outlined some areas of concern and possible guidelines.

RESOURCES FOR THE GOOD LIFE— AN APPRAISAL OF THE 29TH CONFERENCE

WILLIAM E. TOWELL
Director, Missouri Conservation Commission, Jefferson City, Missouri

One cannot but be impressed with the quality of past appraisals of these North American Wildlife and Natural Resources Conferences. More than summaries, they represent intelligent interpretations of material presented and discussions of future implications. However, isn't this the purpose of any conference—to delineate problems and then consider what we might do about them? This conference theme, Resources for the Good Life, *implies* a search for answers to resource problems that will improve man's well-being. Although we might recognize the purpose of the conference and of this critique, who could feel equal to the task? Aldo Leopold, the first to appraise a North American Conference, began: "Only a fool or an angel would attempt to summarize this conference." He, and then many other eminent conservationists to follow, proceeded to set an angelic pattern.

Starker Leopold felt "an unbiased assessment of the wealth of material presented at one of these meetings is impossible for any one man." Clarence Cottam echoed this in 1961 when he described the assignment as "beyond the capacity and reach of any one reviewer."

Nowhere, however, do I find the *administrator's* approach to the task. It is said that the mark of an administrator is not what he *does,* but what he *gets done.* In my review of past appraisels and my search for a new approach, it was obvious I could attend only the two general sessions and half of the technical sessions. Then I discovered three people from my own organization with important conference assignments. Larry Gale, chief of Missouri's Fish and Game Division, was chairman of the Field and Farm Resources session. Jim Keefe, information officer, served as discussion leader in the Conservation Information and Education session. Leroy Korschgen, one of our most reputable biologists, had the lead-off paper in the session on Disease, Nutrition and Control. It did not require great imagination to assign Bob Dunkeson, a waterfowl management biologist, to the Wetlands and Inland Water Resources session, or P. G. Barnickol, Chief of Fisheries in Missouri, to the session on Coastal and Marine Resources; or, John Wylie, Assistant State Forester, to cover the papers on Forest and Range Resources. Then to work with me on the two general sessions, where could one find a better qualified writer and conservation thinker than Assistant Director Dan Saults?

Ladies and Gentlemen, this is the *administrator's* approach to a conference appraisal. It is a team effort. I give full *credit* to those very capable men who assisted me. But, like any administrator should, I take full *responsibility* for the final product. I feel that eight heads are better than one, *if* the efforts are properly coordinated, sufficiently edited, and adequately presented. I offer this critique as captain of the team—as a summarizer of the summarizers.

The Opening General Session traditionally sets the theme of any North American Wildlife Conference. This opening session may not clearly have done so. Despite polished presentations of topics by able and thoughtful men, there was no clear sense of unity and purpose except as unity existed already in the minds of the audience. There was, and is, unity there.

Chairman Irving Fox did keynote it well, with his comments—and I am interpreting as well as condensing—that early pessimism has given way to optimism in terms of food and fiber; we can feed our burgeoning millions, house them and clothe them. But, if we no longer need to cry crisis in terms of nutrition in North America, we must now grapple with the pollutant poisons and aesthetic values, the sheer ugliness that is overwhelming us, that may not, in his words, make survival worth while.

James Gibson, speaking on "Human Needs and Resource Values" referred to the Peace Corps and Poor Corps. It is my personal impression that he hoped to discuss the Administration's projected "War on Poverty" program. But with the battle not yet joined because attack plans are not firmed up, Mr. Gibson spoke eloquently of the Peace Corps, a projection of the goals of President Kennedy, whose real power to move men and nations lay not in our A-Bombs but his *ideas*. This is, of course, a sharing of the responsibility through "practical idealism," to use a Gibsonian phrase, in terms of Peace Corps work with other countries. Incidentally, one of our Missouri Conservation Commission people, Cecil Davis, retired some 18 months ago—joined the Peace Corps, and is now serving in India. All the Corpsmen are not young, obviously, but none could be more dedicated than Cecil Davis.

Bernard Orell spoke on private responsibility for resources from his position as a vice president of Weyerhaeuser Company, saying significantly that controversy over land use should not be discouraged but name-calling should be. In the private responsibility, he felt there were three major points for businessmen: Production, Profit and Cooperation.

Mr. Orell's strength of presentation lay in definition: *Conservation* is the middle ground between preservation and exploitation; *multiple use* is the wisest management of acres if it begins with *primary* functions and then fits in the *related,* non-harmful uses; *Production* demands the best conservation practices because this is the tree-growing principle. *Profit* pays the bills for land and management, but again is best based upon conservation principles—between preservation and exploitation—as a long-range investment in long-range resources.

Dr. Ira Gabrielson reviewed Washington developments, said generally things look fair this session although 1963 was a year of frustration in our field. He praised the late President Kennedy, reported President Johnson had promised to carry on, and lauded Secretaries Udall and Freeman. He then reviewed current legislation.

Compromise is the price of legislative accomplishment but should not sacrifice fundamentals. He then attacked provisions to permit mining and prospecting in wilderness areas, and called for clear wording in the wilderness bill. He supported and urged general support by the professionals of conservation, for a recreation use-fee in the Land and Water Conservation Fund bill.

Dr. Gabrielson also reported we are still failing in our pollution control efforts, and called "of paramount importance" amendment of the Pollution Control Act to provide "a truer direction" in serving the public interest. He praised Agriculture Department efforts to convert unneeded farmlands to recreational use, called for liability relief laws for landowners at state level, cautioned ill-conceived gun laws, and denounced Rampart Dam in Alaska while praising the Louisiana

Wild Life and Fisheries Commission's report opposing the Corps of Engineers proposal on the Atchafalaya River floodway.

Dr. Starker Leopold, as wind-up speaker on the morning session, reported in condensation on the study made by the Interior Advisory Board concerning Predator and Rodent Control in the United States. His report, on a controversial subject, almost certainly will have wide support, and not only because it is made by intelligent, able and knowledgeable men: Stanley A. Cain, Ira Gabrielson, Clarence Cottam, Tom Kimball, and the chairman-spokesman.

Very briefly, Dr. Leopold skillfully and with touches of eloquence stated that predator destruction has become an end in itself, rather than control, that "control" is greatly in excess of need, that there is, in fact, overkill.

The Predator and Rodent Control branch of the U. S. Fish and Wildlife Service was criticized—not always adversely, by any means—and the committee recommended the creation of an advisory board to consider all aspects, including the aesthetics, of predator destruction. The committee felt that bounties are *never* justified. The *"methods"* of control were rated better than *"extent"* of control.

WETLANDS AND INLAND WATER RESOURCES

Papers on waterfowl ranged over all three parts of the habitat problem: production, migration, and wintering habitat. Hansen and McKnight say that dabbling ducks, displaced by drought on U.S. and Canadian prairies, moved to Alaskan duck areas. These far northern marshes are important to a reservoir of breeders which can re-populate the prairie when drought breaks. Does this have implications for the Yukon habitat now threatened by Rampart Dam?

Water areas created by beaver dams in the South can be managed to attract ducks and provide a source of income to the landowner. This is one way Arner proposes to meet the problem of beaver damage on flat southern topography where commercial timber is flooded in beaver ponds.

Bellrose is using bird targets which show up on U. S. Weather Bureau radar scopes to follow waterfowl migration in the Midwest. This new technique smacks of the Space Age; here is a way to get a mass of data on a subject which up to now has been only casually observed.

Conservationists are alarmed by highway construction through valleys with choice trout streams. But Peters and Alvord say that in Montana, railroad construction prior to the 1920's, along with changes in streams by agricultural, urban, and commercial interests, share the blame with road construction for damage to streams.

John Hewlett, at the Coweeta Laboratory, suggests water in headwater streams, ponds, and lakes is an indicator of the long-term success or failure of land management. As the demand for water grows, wildlife managers will have to make their desires for certain vegetation fit with other aims of multiple use, including the yield of water.

Past wildlife conferences have heard discouraging reports on results with the small watershed program, P. L. 566. But the director of the Pennsylvania Fish Commission endorses the 566 projects planned in his state. He describes the program as "a much needed helping hand to provide new fishing and recreational water at a cost within range of conservation budgets."

DISEASE, NUTRITION AND CONTROL

Problems of disease, nutrition and control do not have simple solutions. This session again emphasizes the complex inter-relationships of animal life as related to environment.

Diseases of wild animals continue to be an enigma to game managers and pathologists. Some pathogenic organisms are non-specific in host selection, and may affect many animals. We have made advances in our knowledge of hemorrhagic disease of deer, the *Listeria*-produced encephalitis, septicemia, and meningitis afflictions of man and animals, and the parasitic infestations of wild animals.

Clues to distribution of midwestern pheasants were reported from detailed study of diets by sex, season, age and physical requirements of wild birds.

Side effects of the Atomic Age were shown by description of food chain relationships in Alaska. The long-term effects of radioactive fallout remain to be assessed, but must be kept under surveillance in resource management.

FIELD AND FARM RESOURCES

Field and farm research points the way toward providing *Resources for the Good Life*. Wildlife is a product of the land and its abundance is governed by the uses to which land is put. A wildlife manager may manipulate habitat to better meet requirements of species present, or introduce animals better adapted to existing conditions.

Wildlife management must compete with other uses. Forests can produce more wildlife with relatively minor changes in timber management but agricultural lands present a more difficult problem, because wildlife management may require direct cash expenditures and reduce crop income. Thus direct game management is applied to few farms. Population levels of upland game is more dependent on broad agricultural trends than on any other factor.

Lands available for *direct* game management, especially those in public ownership, must be managed more intensively to provide more hunting opportunities. There is need for stronger cooperative efforts between state wildlife agencies and those federal agencies which manage lands or influence practices on private lands, although cooperation is generally good in most areas. Probably the greatest inconsistency is the federal drainage program, which destroys essential wildlife habitat.

Cooperative state-federal programs are the trend of the present and the future in resource management. This is good, as long as we delineate functions that properly belong to a single agency; everybody's job often deteriorates into nobody's job.

Land use trends will bring significant changes in the game available for hunting. In some instances animals formerly extirpated are being restored to ranges again capable of supporting them. Other animals decline or increase in response to changes in habitat. A resource manager must point out neglected opportunities to hunters to make use of the game that his hunting area offers instead of wasting money in futile efforts to provide game that the habitat cannot sustain.

Efforts to establish exotics will continue in spite of a high rate of failures. There will be successes as well, possibly approaching the ring-necked pheasant in importance.

There is justification for confidence that scientific management will provide a continued supply of *Field and Farm Resources for the Good Life.*

COASTAL AND MARINE RESOURCES

Marine resources can provide much of the food required to meet worldwide need, but only 15 per cent of the potential is being utilized. Distribution and preservation limit the use of sea foods. There is competition for this resource in productive marine areas, and it is unrealistic to consider the oceans inexhaustible. It seems obvious that world management is mandatory if we are to feed two billion chronically undernourished people.

There are advances in preservation of marine products and in artificial propagation of shellfish and other invertebrates. But we have barely scratched the surface here.

Water is used intensively in outdoor recreation. Although water is not consumed, space is; and it is intensely competitive with food production, hunting, fishing, and esthetics. These uses represent values that rest on good water quality.

FOREST AND RANGE RESOURCES SESSION

Papers presented at the forest and range resources session included reports on both basic and applied research.

From the life history papers we learned that deer, like humans, and other animals, seek shade when they are hot and sunlight when they are cold. Also deer respond to a chill factor or comfort index as I do. Temperature, humidity and wind influence this, naturally.

Ghosts of by-gone years were raised by a woodland paper on the one hundred or so caribou which tread a "roam range" of 30,000 square miles of dark and mossy forests in the Northwest. With lichens as their winter food they are necessarily creatures of the mature forest. Management is not practical; their only chance of survival is ceaseless wandering.

One basic fact evident in habitat is change—change in land use patterns and intensity of use. Wildlife can't be considered an accidental by-product of other forms of land use. Patterns of change must be carefully evaluated in terms of wildlife requirements and management practices. Brush control can become brush management. Deer and elk do not compete with cattle on all sites and in all cover. Steep slopes, particularly those with northern aspects, and ridges with suitable vegetative types should be managed for the game species that actually use them. Described briefly this means multiple management for multiple uses. Timber, livestock and game habitat improvement practices must be coordinated for really complete land utilization.

Now to our market place: the harvester-hunter. Too often in the past farmers, foresters, and biologists have only been concerned with "producing." There is no point in *production without markets* for the products. We can either create markets for existing products or produce products for existing markets. In either case, our end market is the harvester-hunter, but what do we know about him? What is his idea of the product he wants to buy? Enlarged research in this field can help answer these questions.

We have learned that hunter access is important for adequate, well distributed deer harvests—particularly when the urban hunter is the harvester. Trails are used equally with roads and since trail construction is cheaper, more trails may be the answer to distributing hunters.

Robert Davis's paper emphasized to me that we are actually marketing *opportunities to hunt* (perhaps *pleasurable experiences* is a more descriptive term). His economic study revealed that the length of stay and past experience influenced the hunter's willingness to pay for his hunting experience. Demand for this outdoor recreation increases with the hunter's income.

Mr. Davis correctly said, "I think that many of our wildlife production and harvesting problems can be solved through more reliance on market processes and the production incentives that accompany opportunities for private gains."

CONSERVATION EDUCATION AND INFORMATION

Although the conservation movement is at least fifty years old, there is no great groundswell among our citizens in favor of it. There are many different conservation organizations. They tend to "Balkanize" themselves, each riding its own hobby and excluding the other. None of them is especially effective.

Conservation battles are won and lost without people knowing we're at war.

This is odd, because the charge about apathetic Americans is largely untrue. People *are* concerned and apprehensive, though not about *our* problems. They feel things aren't as good as they could be, they lash out but never effectively come to grips with things. People are there to be led *if* leadership is skilled enough to identify, involve and catch up with those people. This is the challenge for conservationists who want to be heard.

Important segments of our society are uninterested in the problems facing mankind and his resources. The teaching profession tends to skip serious conservation teaching, and the best education medium after school, the newspapers—are also disinterested in resource management.

When President Johnson took the reins of government much was written on his views on various subjects, but not one word of copy on his resource views was asked for by the press, or printed. The Washington press corps, the nation's most knowledgeable, just didn't consider it.

Information and education efforts are a part of most departments, but success has been less than it could be. We have been talking too much to ourselves—possibly we've been too narrow in our approach, too much specialized; we need more "generalists" in the wildlife field to bring breadth of understanding and public communication.

We have not seized all our opportunities. There are many groups not yet motivated toward resource conservation. We've been scattering our shots too widely in trying to interest the mass, rather than concentrate on the active leaders of people. Small groups *can* wield great power, if they're motivated, and skillfully lead.

More emphasis should be on knowing where *we* want to go. Too many departments have nebulous ideas of their goals.

Once definite goals are established we need to know our audience and how effective our approaches have been. And we must have some sort of "feed back" so we can assess our efforts as we attempt to sell resource management.

SECOND GENERAL SESSION

The address by Stewart Udall, read by Sig Olson in the Secretary's absence, speaks as well as "The Quiet Crisis," and follows the same theme—as it should have done. Here was the true keynote of this conference, and perhaps as good as a summary. Because again and again, in meeting after meeting, I heard the idea that the Secretary of Interior hit so well with his statement: "The real challenge now and in the future is to project conservation into the mainstream of American life."

Mr. Udall is eloquent and yet tough-minded; he can speak of beauty in life, and still know that the price of beauty is great—while knowing also that aesthetic values are worth what they will cost in dollars. You have just heard the speech, and surely most of you have copies of it, but I must repeat, if only for emphasis, that the real conservation fight today is for the creation of a livable total environment, for the wisdom to preserve an environment in which a beautiful life is possible.

The other speeches of this afternoon have ended so recently that a summary hardly is needed. I would like to comment that Professor Dils call for "specialized generalists" was echoed in the I & E session this morning—and aside from the grammatical horror of the term, the idea is most sound. We certainly need Men of the Renaissance to synthesize our multitudinous research and our polygot ideas into a coherent and operational whole. I am fearful—a little fearful, at least—that we may be approaching a stage in which research becomes an end in itself, an activity automatically "good." Mr. Kramer has noted this also; he set up guidelines in his speech.

And Mr. Pechanec, in discussing vegetative research, made a point that bears wider application: man's shifting modes of life keep creating new environmental problems. Man's use of resources keeps creating new administrative problems, too, and game and fish and political and psychological problems. We will never have a simple answer to complex problems. As Dr. Yambert said this morning:

"Simple answers to complex problems have three attributes: they are easy, clear—and *false!*"

My invitation to critique this conference came because of my capacity as a state wildlife administrator. For a final appraisal, let me outline briefly the continent's major problems as viewed by a state director. These represent the challenge:

Pollution—The greatest resource problem in America today is water pollution. Menace to health and wildlife, obstacle to industry, ruination of recreation—pollution demands our first attention. We're beginning to make progress, but efforts must be intensified. Let's get pollution abatement on an administrative and budgetary status commensurate with its importance. The responsibility must be shared on a municipal and state level and by industry, but spearheaded on a national scale. In spite of growing organized opposition, conservationists need to achieve a stronger federal pollution control administration.

More wildlife habitat is destroyed each year by pollution than is created by private, state and federal conservation activities combined. Hewlett in the Wetlands and Inland Water Resources session warns that "any practice which damages the water resource cannot fail in the long run to damage total values of the land." Massmann stated in the session on Coastal and Marine Resources that "Among the man-created environmental factors affecting the abundance of estuarine and coastal fishes, pollution is the most serious." I witnessed with personal alarm last year in Hawaii almost complete destruction of oyster beds in Pearl Harbor and limited recreational use of shorelines on the big island of Hawaii by municipal, industrial and agricultural pollution.

Air pollution, too, must come into consideration for greater concern. Kramer told us in this afternoon's session that "contamination of the air by smog and other industrial wastes probably is a more serious threat to human health and comfort than radioactive fallout."

As a part of the whole pollution problem special concern also must be reserved for pesticides and their residual concentrations in our environment. "Silent Spring" is not fiction. We are on the threshhold of alarming new disclosures of chemical toxicants in our soils and waters.

Waterfowl—The emergency program to save America's waterfowl is failing. It lacks sufficient appropriations to buy duck breeding potholes in the United States. It is stymied by law that permits state blocking of vital federal land purchases. Failure, too, comes from lack of any real international action program with Canada and Mexico. In spite of many years effort we still are unable to get federal legislation to preserve Tule-Klamath, the most important waterfowl concentration area in the Pacific Flyway. Current drought problems are minor compared with permanent drainage, filling and pollution of waterfowl marshlands. We have barely stopped subsidies promoting some of this destruction.

Public Lands—Exploitation of public lands for private gain is a never-ending threat. Here, ours is a watchdog responsibility. Mining, grazing, road building, timber harvest, and water impoundment are all good in themselves. It is only when they are exercised to the extent of destroying public values that they demand our attention. And, there will always be such problems demanding our attention. It seems incredible that we are still without a satisfactory wilderness preservation law. No move is being made to create vast new wilderness areas, only to insure permanent status of those we already have. But the bill still languishes in Congressional committee.

Recreation—Accelerated federal emphasis on outdoor recreation comes none too soon. We are already decades behind in setting aside lands and waters for public use. We have vast areas of public lands, but largely where *people are not*. A growing army of campers, picknickers, hunters, boaters, hikers, fishermen, and just plain sightseers need facilities on lands already publicly owned. Recreation is not the opposite of industry, wealth and national strength. It is health and happiness, contributing to the total well-being of an exploding population that needs its tranquilizing value. It truly represents use of Resources for the Good Life. Yet, there is serious opposition to a Land and Water Conservation Fund bill in Congress because some feel there should be no users fees charged for recreational facilities developed on public lands for their use.

With all the current emphasis on outdoor recreation we must not overlook the refreshing tonic of solitude. Are we making best use of our public recreational lands by *concentrating* people on only a fraction of this area? True, we need picnic areas, camp grounds, swimming beaches, boat harbors, and all the rest, but let's not overlook the need for dispersing people.

Government—The great danger in what we have said thus far is the possible implication that vast federal programs will solve all our resource problems. On the state and local levels we cannot ignore our responsibilities to manage resources. By tradition resident wildlife belongs to people under state jurisdiction. States must guard this trust carefully. Too much dependence upon federal management, regulation or subsidy could lead to abdication of state control. Management of animal populations, except certain migratory species, should remain with the states. Hunting as a traditional form of outdoor recreation should be retained on all new federal areas where there is no full-time conflict in land use. Laws and licensing for the taking of fish and game must remain a state's right. On the other hand, this entails state responsibility for management programs and research. Big brother, in the form of federal government, is a welcomed partner but must not assume the role of command through default of the states.

Education—In a listing of major resource challenges, I must include conservation education. In the final analysis it is awareness of our resource problems that will bring about their solutions. The story of land and water abuse must be told. Are we getting this job done? Perhaps Russ Lynch is correct in his suggestion of "an urgent need for unified action by all conservation organizations." Perhaps they could all join in a conservation education year as the start of a continuing unremitting effort to expand the three R's to four: Reading, 'Riting, 'Rithmetic—*and Resources.*

No finer closing words can be found than those of Aldo Leopold in his introduction to *Sand County Almanac*: "Conservation is getting nowhere because it is incompatible with our Abrahamic concept of land. We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect." This is the concept we must teach.

CLOSE OF THE 29TH CONFERENCE: FORMAL ACKNOWLEDGMENT OF APPRECIATION FOR COOPERATION

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

Speaking for the Wildlife Management Institute, which, sponsors these international conferences each year, I wish to thank my good friend, Bill Towell, for an outstanding critique and summary of the overall program of the 29th Conference. Bill, you did an excellent job, and all of us appreciate the skill with which you handled a very difficult task. Those of us who stage these yearly conferences know how much hard work and time must be applied by the summarizer, and we are indebted to you for a superlative presentation.

Our sincere thanks also to The Wildlife Society, especially to Robert H. Bendt, who represented the Society as Chairman of the program of the Technical Sessions. The members of the Program Committee, which is made up of the heads of most of the national organizations and federal agencies, also deserve thanks for their contribution to the success of this conference.

We are grateful to the working press, especially the newspapers of Las Vegas, and to the wire services, which, I understand, have given considerable coverage to the meetings. Dan Poole, who was recently made the Secretary of the Institute, worked hard to provide reporters and feature writers with copies of papers and abstracts as many news releases.

I am certain that all of you agree that the "Sahara Spectacular Floor Show" last night was the finest ever staged in connection with one of these conferences, and we are indebted to the hotel for making its show available, as well as for its assistance in meeting the needs of the conference for space and facilities. Thanks to Desmond Kelly and his staff in the Las Vegas Convention Bureau for the efficient and courteous handling of the registration details. John Goodwill, the assistance manager of the Convention Bureau, also did much to promote "good will" for Las Vegas.

I also want to thank the members of the Ladies Committee and also all of the others who have helped to make this conference such an outstanding success.

With regard to these meetings, the attendance at the individual meetings has been truly outstanding, especially when you stop and think of the competition that has been presented to you while you traveled back and forth between the two meeting rooms. This has been quite a temptation that you folks have had to undergo and, nevertheless, you have stayed religiously with us.

Also, the attendance here during this hour of this afternoon and at the final closing session, I believe, is truly outstandnig.

Therefore, thanks again for your interest and cooperation in mak-this conference such a success.

I believe the attendance this year has been above average. We have certainly had around twelve to thirteen hundred people. The registered attendance at final count was 1076. However, I am confident you will agree that at the opening session we had around twelve to thirteen hundred people in here. Also, the crowd at the banquet last night was the maximum. They had 676 places in there and we put in 679 people.

Now then, for next year, we are going back to Washington. We have had to make a switch. The new Statler-Hilton, where we had our reservations for next year, is only about half done right now and so we have switched back to the old hotel where we have been before.

The date for next year's convention will be March 8th, 9th and 10th and we hope to see you all there.

Best wishes, thank you again—and happy landings.

REGISTERED ATTENDANCE AT CONFERENCE

ALABAMA

George W. Allen, Ralph H. Allen, Jr., George A. Averitt, Mrs. George Averitt, Maurice F. Baker, I. B. Byrd, F. H. Farrar, W. L. Holland, Raymond D. Moody, Ion Walker.

ALASKA

Ed Bellringer, Mitchell M. Berkun, Bud Boddy, Mrs. A. W. Boddy, James W. Brooks, Richard A. Cooley, Frederick C. Dean, Dr. William M. Dickson, Albert W. Erickson, David R. Klein, Sig Olson, Don H. Strode, Gordon W. Watson.

ARIZONA

Wayne Anderson, O. N. Arrington, Tom Barnes, Jim W. Barrett, Sandy Barrett, Bud Bassett, Bill Bigler, Richard A. Bishop, Jim Blaisdell, Wally Breese, Bud Bristow, Dave Brown, Louis H. Carufel, Ron Clothier, Phil Casper, Robert D. Curtis, Jane A. Lee Curtis, Jerry Day, Gordon Evans, Milton G. Evans, Fred Farnbach, Wes Fleming, Steve Gallizioli, John R. Hansen, Mrs. Rex Hansen, Lee Hover, Roger Hungerford, Glen F. Ingle, H. D. Irby, R. A. Jantzen, Martin Johnson, Pat M. Kelly, Wayne Kessler, Terry Landrith, Paul A. LeRoux, Clay McCulloch, David W. McDaniel, Ralph P. Malsam, Ross Manes, Don Miller, W. L. Minckley, Peter H. Momsen, Don J. Neff, Levi R. Packard, Mrs. Donna Packard, C. M. Palmer, Jr., Mrs. Dorothy G. Palmer, Larry Powell, Harold Pratt, Mrs. Neva Pratt, Jerome J. Pratt, Mrs. Evelyn Pratt, A. B. Queenan, Albert Romeo, John P. Russo, Daniel P. Schadle, Harley Shaw, Bill Sizer, O. M. Sizer, Don Smith, Mrs, Lucia Smith, Mrs. Robert J. Smith, Ronald H. Smith, Cliff Sorrels, Lyle K. Sowls, Wendell G. Swank, Mrs. Wendell G. Swank, Dick Todd, Charles Wallmo, Edward L. Webb, Paul M. Webb, Fred J. Weiler, George W. Welsh, Bob White, Mrs. Eva White, Alan Wick, N. C. Williams, Dale L. Wills, Don Wingfield, Mike Yeager.

ARKANSAS

William J. Allen, Mrs. Peggy Allen, W. M. Apple, Nelson Cox, David Donaldson, Mrs. David Donaldson, D. N. Graves, Newt L. Hailey, Ernest E. Hogue, J. Sam Holt, Mrs. Virginia Holt, Pat O'Halloran.

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