TRANSACTIONS

of the

THIRTY-FOURTH NORTH AMERICAN WILDLIFE AND NATURAL RESOURCES CONFERENCE

Conference Theme:

CONSERVATION IN AN URBANIZING SOCIETY

MARCH 2, 3, 4, 5, 1969

Washington Hilton

Washington, D. C.

Edited by James B. Trefethen

Published by the
WILDLIFE MANAGEMENT INSTITUTE
WIRE BUILDING
WASHINGTON, D. C. 20005
1969

Additional Copies may be procured from
WILDLIFE MANAGEMENT INSTITUTE
Wire Building, Washington, D. C. 20005
for $5.00 Postpaid

PRINTED IN
U.S.A.
by
MONUMENTAL PRINTING CO.
Baltimore, Md.

WILDLIFE MANAGEMENT INSTITUTE

OFFICERS

IRA N. GABRIELSON, *President*
C. R. GUTERMUTH, *Vice-President*
DANIEL A. POOLE, *Secretary*
H. L. HAMPTON, JR., *Treasurer*

Program Committee

C. R. GUTERMUTH, *Chairman*

WALTER O. HANSON, *representing* THE WILDLIFE SOCIETY *as Chairman of the Technical Sessions*

STEWART M. BRANDBORG, *Executive Director*
The Wilderness Society, Washington, D. C.

DAVID R. BROWER, *Executive Director*
Sierra Club, San Francisco, California

CHARLES H. CALLISON, *Executive Vice President*
National Audubon Society, New York, New York

HOMER CIRCLE, *Past President*
Outdoor Writers Association of America, Rogers, Arkansas

EDWARD P. CLIFF, *Chief*
U. S. Forest Service, Washington, D. C.

RODOLFO HERNANDEZ CORZO, *Director General de Caza*
Recursos Forestales y de Caza, Mexico, D. F.

EDWARD C. CRAFTS, *Director*
Bureau of Outdoor Recreation, Washington, D. C.

FRANK C. DANIEL, *Secretary*
National Rifle Association of America, Washington, D. C.

WILLIAM C. DILLINGER, *Past President*
American Ass'n for Conservation Information, Sacramento, Calif.

HARDIN R. GLASCOCK, *Executive Secretary*
Society of American Foresters, Washington, D. C.

GEORGE B. HARTZOG, JR., *Director*
National Park Service, Washington, D. C.

DAVID A. MUNRO, *Director*
Canadian Wildlife Service, Ottawa, Canada

CLARENCE F. PAUTZKE, *Assistant Secretary*
Department of the Interior, Washington, D. C.

JOSEPH W. PENFOLD, *Executive Director*
Izaak Walton League of America, Washington, D. C.

H. WAYNE PRITCHARD, *Executive Secretary*
Soil Conservation Society of America, Ankeny, Iowa

BOYD L. RASMUSSEN, *Director*
Bureau of Land Management, Washington, D. C.

THOMAS W. RICHARDS, *President*
The Nature Conservancy, Washington, D. C.

THOMAS G. SCOTT, *President*
The Wildlife Society, Corvallis, Oregon

WALTER T. SHANNON, *Past President*
Int'l Ass'n of Game, Fish & Conser. Comm., Sacramento, Calif.

ANTHONY WAYNE SMITH, *President*
National Parks Association, Washington, D. C.

LLOYD L. SMITH, JR., *Past President*
American Fisheries Society, St. Paul, Minnesota

SPENCER M. SMITH, *Secretary*
Citizens Committee on Natural Resources, Washington, D. C.

RICHARD H. STROUD, *Executive Vice President*
Sport Fishing Institute, Washington, D. C.

WILLIAM E. TOWELL, *Executive Vice President*
American Forestry Association, Washington, D. C.

RUSSELL E. TRAIN, *President*
The Conservation Foundation, Washington, D. C.

DONALD A. WILLIAMS, *Administrator*
Soil Conservation Service, Washington, D. C.

ROBERT WINTHROP, *President*
North American Wildlife Foundation, New York, New York

GORDON K. ZIMMERMAN, *Executive Secretary*
Nat'l Ass'n of Soil Conservation Districts, Washington, D. C.

DONALD J. ZINN, *President*
National Wildlife Federation, Kingston, Rhode Island

Ladies Committee

MRS. IRA N. GABRIELSON
MRS. C. R. GUTERMUTH
MRS. WALTER O. HANSON
MRS. DANIEL A. POOLE

● ● ●

The Wildlife Management Institute expresses its appreciation to The Wildlife Society and to the many organizations and individuals who contributed to the success of the 34th North American Wildlife and Natural Resources Conference.

CONTENTS

PART I—OPENING GENERAL SESSION
FACING RESOURCE CRISES IN THE 1970'S

PART II—TECHNICAL SESSIONS
COASTAL AND MARINE RESOURCES

DISEASE, NUTRITION, AND CONTROLS

PESTICIDES—NEW FACTS AND OLD PROBLEMS—A PANEL

FIELD AND FARM RESOURCES

MEASURING WILDLIFE VALUES—QUANTITY AND QUALITY

WETLANDS AND INLAND WATER RESOURCES

FOREST AND RANGE RESOURCES

PRESCRIBED BURNING FOR WILDLIFE—A PANEL

PART III—CLOSING GENERAL SESSION
ACTIONS NEEDED FOR THE TASKS AHEAD

PART I
OPENING GENERAL SESSION

GENERAL SESSION

Monday Morning—March 3

Chairman: ALAN SIMPSON

President, Vassar College, Poughkeepsie, New York

Vice Chairman: CLIFFORD G. MCINTIRE

Director, Natural Resources Department, American Farm Bureau Federation, Chicago, Illinois

FACING RESOURCE CRISES IN THE 1970'S

FORMAL OPENING

C. R. GUTERMUTH

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

It is a pleasure and privilege to open the 34th North American Wildlife and Natural Resources Conference. We are delighted to see so many people here at this opening session, not only from the various states and from Canada and Mexico but, I understand, from a number of nations of five other continents. Many are old friends who have attended all or most of these meetings; a few since the days of the American Game Conferences that were held before 1936. Others are attending for their first time.

As all of the old-timers know, it has become customary to return this international conservation meeting to Washington, D.C. every four years. The location in the nation's capital this year is particularly appropriate. We have a new leadership in top echelons of some of the federal natural resources programs as well as a new national Administration. It is certain that there will be changes from the past in perspective as well as in policy as there is after every major change in executive leadership. I am sure that we shall have a better understanding of the direction of our future conservation progress after this morning's session.

We have outstanding panels of speakers to enlighten you today and for the next three days. For the information of those who are unfamiliar with the Conference, the program is developed by the General Committee, the membership of which is composed of the ranking officials of most of the larger national conservation organizations and the principal administrators of the governmental natural resources agencies in the three nations of North America. The Wildlife Society was very ably represented this year by Walter O. Hanson of the U.S. Forest Service.

For the benefit of newcomers in the audience, I must point out that the North American Wildlife and Natural Resources Conference is a public forum and clearing house for information on all aspects of conservation and management of renewable natural resources. It is not a convention, and for this reason it does not pass resolutions or take action of any kind. All of the chairmen had been instructed to rule out of order anyone offering resolutions from the floor. If the presentations and discussions of the next three days inspire action by the individual organizations and agencies represented in this audience by their officials and members, we shall be delighted. But the Conference itself does not take any action.

All of you are urged to use the discussion periods provided in the program to ask questions or to comment on the presentations of the speakers. We request that you identify yourself for the benefit of the reporter by name and by affiliation or state. All discussion will be published in the Transactions of the Conference, which will be made available at cost.

Before I turn the meeting over to the distinguished chairman of the opening general session, it is necessary to make a few announcements. There is no registration fee, and all meetings are open to the public without charge or restriction. We ask that you stop at the registration desk and sign in so that we can obtain an accurate count of the attendance and representation by nation, state and organization. It also may be necessary to reach you in the event of an emergency.

Visiting ladies are invited to be the guests of the Wildlife Management Institute at a luncheon at noon today in the Jefferson East Room. Tickets must be picked up at the registration desk before 10:00 a.m., since we must give a guarantee to the hotel.

The annual reception and banquet of The Wildlife Society will begin at 5:30 this evening in the Crystal Room. Those who wish to attend may purchase tickets at the Society's desk on the concourse floor.

The annual banquet of the Conference will be held in the Ballroom tomorrow evening. There will be no speeches, but you will have an opportunity to relax with old or new friends and enjoy an excellent meal and a good musical and variety show. This is the social highlight of the Conference. We expect a capacity crowd, and everyone who wishes to attend should obtain his ticket as early as possible to avoid disappointment.

In behalf of the Wildlife Management Institute, which sponsors these annual meetings, I welcome you to the 34th North American Wildlife and Natural Resource Conference. I now turn the meeting over to the chairman of the opening session, a distinguished educator, Dr. Alan Simpson, president of Vassar College.

REMARKS OF THE CHAIRMAN

ALAN SIMPSON

Ladies and gentlemen, it is a great pleasure for me to be chairing this session. If you are a little curious as to what a college president is doing here, let me say that there is no time in the history of higher education in this country when a college president stood more in need of a course in wildlife management.

It is my privilege to introduce the four distinguished authorities who will address themselves to the theme of this general session—"Facing the Resource Crisis of the Seventies." This is a rather fitting program. Each of our panelists has been invited to take thirty minutes to make his presentation. He will then be followed by ten minutes of discussion.

I now introduce to you the Vice Chairman of the session, Mr. Clifford G. McIntire, Director, Natural Resources Department, American Farm Bureau Federation, Chicago, Illinois. He is a familiar figure here and will assist us with the discussion.

Now, may I introduce Mr. Douglas Brooks, President, The Travelers Research Center.

MAN'S RIGHT TO A CLEAN ENVIRONMENT

DOUGLAS L. BROOKS
President, The Travelers Research Corporation, Hartford, Connecticut

As this nation approaches the 200th anniversary of its first revolution, the one for Independence, it is evident that a second and perhaps even more portentous revolution is gathering speed and force. The Declaration proclaiming the inalienable and suddenly self-evident rights for which the first was fought mentioned "life, liberty, and the pursuit of happiness." In his recent book, "1976: Agenda for Tomorrow," Stewart Udall (1968) stakes his claim as the Thomas Jefferson of today's revolution. His call is for a War of Interdependence to gain for all of us the suddenly precious and self-evident right to a livable environment, a right obtainable only by collective action on a variety of scales up to and including the scale of the planet itself.

In his prologue, Mr. Udall identifies the enemy as waste . . . "the waste that allows madmen to destroy the lives of our most promising leaders; the waste of the human potential of the Indian, the Negro, and the 'permanent' poor (who could do so much to enrich our national life if they were only given the chance); the waste of affluence through misdirection; the waste of beauty and order and cleanliness of the land, and, above all, the waste of the clear and present opportunity to build, on this continent and in this country, a civilization that could make us, once again, 'the last, best hope of earth'."

When I was asked to speak on man's right to a clean environment, it was not intended, I'm sure, that I take such a sweeping view of the subject. Granted that a clean environment can be defined as one free of "useless, unneeded, superfluous, discarded, excess matter"—that is, waste; using Udall's rather metaphysical defintion of waste to introduce the subject may seem more like a play on words than an operationally useful setting for this discussion.

There are two reasons for wanting to broaden the subject beyond that of the obvious need to prevent excess accumulations of the familiar solid, liquid, or gaseous discards of our industries and municipalities in a familiar pollution control framework.

- First, it is now widely recognized that the deterioration of both natural and man-made components of our physical environment is creating a crisis whose dimensions greatly transcend the traditional problems of polluted air, water, and soil.
- Second, it is also becoming widely recognized that we are not likely to solve these traditional problems of environmental cleanliness

until we face up to the broader objectives of environmental quality control in more comprehensive terms.

AN APPROACH

If improved management of our environment is the need, then the framework of management science, long-range planning, and systems analysis may be useful to our thinking. This framework most simply tries to answer three questions. In the environmental context they are:

1. What are the trends that characterize the changing natural and man-made environments which man will inhabit in the next several decades?
2. What is the possible range of alternative future environments?
3. What might be done to influence these trends so as to shape the future in desirable directions?

These three technical or managerial questions are imbedded, of course, within a transcendently difficult fourth question that lies largely outside analysis. This is the question of what is desirable. What environmental alternatives should we take as our goal? The answer lies in the realm of values and has social, economic, and political aspects as well as personal or individual psycho-physiological ones. Here technology and systems analysis fail us, and our surest guides, if we can trust any, are psychology, anthropology, ethnology, philology, mythology—the name we give to the theologies of others—and literature and art. One way of posing this fourth question is: What are man's environmental rights? I would have you note that in this form it becomes a question in ethics.

We are not going to probe the depths of this subject in either its managerial or ethical forms in this short talk. In any case, the literature is as yet too fragmentary and partial to support a rounded view of the subject, although a heartening advance is taking place. I shall try instead to make some suggestive remarks on each of the four questions posed, to illustrate the kind of answers that further work may improve upon. This work is going on in many places—Resources for the Future, RAND, universities, and federal agencies, as well as in my own organization—and it seems clear that a new field of scientific and professional activity is beginning to take shape, that of environmental management.

DIMENSIONS OF CRISIS

A considerable literature, to which I have contributed, is beginning to develop on the nature of the trends that characterize the gathering environmental crisis. There is as yet no uniformly accepted way of classifying the symptoms of environmental deterioration. I have suggested a fivefold classification that seems to me to lend itself to management considerations (Brooks, 1967):

1. The impoverishment of our resources—there has always been reason to worry about the impoverishment of our so-called non-renewable resources: minerals, gas, oil, and the like. There is an increasing list of domestic shortages for which we must go to troubled areas overseas, but so far technology is keeping up with this process, postponing the evil day of bankruptcy. Recently it has become clear that our *renewable* resources are in more critical condition. These are those resources necessary to life: air, fresh water, the soil itself, wildlife, vegetation, complex and fragile estuaries vital as nurseries for so many marine species of immense importance.

2. A special form of assault on our renewable resources takes the form of pollution, a second symptom of environmental decay. Air pollution, water pollution, and soil pollution are all being produced by the increasing amounts of solid, liquid, and gaseous wastes being poured into the environment. Lake Erie is dead, and Lake Michigan is dying of pollution right now. Thermal waste from power plants or sea-water desalting installations must be dealt with. Noise is increasingly being thought of as a form of pollution.

3. Someone has said that the most basic form of pollution is people. Too many people overload the environment in many ways. In a social sense, too many people are perceived as congestion, crowding, and conflicts over the use of space, the third symptom of environmental decay. And now there are about half as many cars as people, and they *actually take up more space,* greatly intensifying the competition. Both physiological and emotional damage is likely from this kind of environmental decay.

4. Alienation is in part a product of the crowding and congestion. But it is also induced by the increasing depersonalization of modern life, the fourth symptom of environmental decay. The sheer size of cities, buildings, institutions, the omnipresence of machinery, the interposition of mechanical communication devices between people, such as the telephone, TV tube, and now the computer, all constrain, structure and render flat and thin the contacts from personality to personality that we seek and need if we're to remain human.

5. Fifth and last is the kind of environmental decay that is developing slowly and almost imperceptibly but which, by the time it's perceived, may have proceeded beyond the point of no return, posing mankind with a catastrophe of truly Wagnerian proportions. This is inadvertent climate modification on a planetary scale. The most serious cause identified at the moment is the measurable accumulation of excess carbon dioxide in the atmosphere from the products of indus-

trial combustion. Carbon dioxide acts as a greenhouse or blanket holding the earth's heat back from radiating to space. Relatively small accumulations could, over a period of years, raise the earth's temperature enough to begin melting the Greenland and Antarctic ice caps, ultimately releasing enough water to raise the sea level a couple of hundred feet. Other pollutants in the air may counterbalance or even reverse this effect, however, acting as a veil to shade the earth from the full effect of the sun's rays.

ALTERNATIVE ENVIRONMENTS OF THE FUTURE

There is far more agreement on these trends than there is on where they are taking us. In my opinion, it is time for a serious and intelligent effort to assemble and apply the information and methods of all the sciences to identity the possible future environments contained within the seeds of the present. I am aware of the great reluctance of scientists to take this kind of plunge. First, the data and dynamic models needed are limited and must be filled in or extended by hypotheses and guesses, incapable of the kind of verification demanded by the rules of the scientific game as traditionally played. Second, this new game of plausible speculation is far better played by non-scientists, anyhow, and a kind of Gresham's law operates to drive the more sober, factual projections out of circulation and keep the glamorous or sensational ones in. Yet the effort must be made, and has scarcely been begun.

To promote this effort, I should like to suggest here that attention be paid to six distinguishable future environments which could stem from present trends. Three are cataclysmic, and it may not be possible to avert them. Yet it may, given sufficient understanding in time. These three catastrophic possibilities are:

1. An environment consisting largely of radioactive ash resulting from the altogether possible nuclear holocaust which modern man is quite capable of unleashing. Wiesner and York (1964) have concluded that there is no technological solution to this environmental threat; that its prevention lies wholly in the political sphere. Presumably, statesmen the world round are staying awake nights attending to this problem, now.

2. A planetary flood resulting from the melting of the ice caps, should the greenhouse effect of carbon dioxide prevail over the solar radiation back-scattering effect of other forms of air pollution.

3. A new ice age, should the reverse of condition two turn out to be the case.

These threats could at least be understood by science and technology, given the effort. The so-called World Weather Watch and the international program known as the Global Meteorological Experiment (GLOMEX), tentatively planned for the mid-1970's, could go a long way toward resolving current questions about the magnitude and even the sign of the relevant trends. Meanwhile, much progress could be made by computer modeling experiments, if meteorologists would forego their decades-old preoccupation with improving the daily forecast and address the broader question of long-term man-influenced climatic change.

Three other environmental alternatives, evolving more directly as the result of man's multifarious activities, can be seen. They are:

4. A septic environment resulting from the overloading of the life-support capacity of the environment by pollution and the re-establishment of high death rates and high morbidity as population limiting factors. I believe those who have been watching the emphysema and lung cancer statistics, for example, or the water quality statistics, realize the prospects here.

5. A sterile environment that might result, should we be successful in dealing with the pollution threat but ignore the other trends noted in the beginning. The means for doing this will most likely be built on waste-recycling industrial complexes, where government and industry will join forces in determining both the product and the market (Brooks, 1968). The tradition for such public-private collaboration already exists in this country and goes a long way back in defense. Since World War II, it has come to include the vast atomic energy business and the even vaster space program.

If the effort at dealing with the environmental crisis stops here, it will, I expect, lead to a further hypertrophy or gigantism of our industrial and governmental institutions through a misplaced trust in technology and engineering to solve the problem. Engineering and technology are very good at finding least-cost solutions, in a dollar sense, and the so-called economies of scale operate to promote ever more comprehensive "systems"—as the smaller local and single-purpose systems of an earlier generation produce unwanted side effects that must be dealt with at some higher echelon of control.

But this gigantism of our institutions and systems is, I believe, one of the major causes of alienation and the present revolt among the minority groups everywhere—like the young around the world. I believe it is largely fear that is driving this revolt, and I believe size is frightening for two reasons. First, these giant systems appear to respond only to numbers of people—that is, mobs—not to individuals, and therefore threaten, by their insensitivity, the very things that distinguish one individual from another. Second, their unreliability or outright fragility is frightening. The power blackout of three Novembers ago in the Northeast is a relatively harmless example. The fragility of the world monetary system is a potentially grave one. It is in a sense outrageous—and frightening—that it depends as much on a strong franc as a strong dollar, and thus ultimately on the willingness of the French to forego another financially disruptive national strike like the one last spring, or the Chinese to forego brandishing, much less using, their nuclear weapons. As our lives become dependent on a relatively small number of gigantic but unreliable systems we become more totally vulnerable to their increasingly possible failure—and this is indeed a justifiable cause for fear and protest.

Is there a *sixth alternative*, one in which technology could serve our needs as in alternative five, but where communities could remain scaled to human size and need, and our lives be clearly and obviously anchored in the kind of direct physical and emotional contact with each other and with nature that man's nature seems to want; that is, a genuinely liveable environment? Of course there is, but it waits the creation of an image of what it could be and thus how to achieve it. There are some clues, of course. I shall mention only two. First is the work of Doxiadis on the technical or design level. In general, as in a a recent article in *Science,* he would have us start with the urban environment, rescaling its component parts to fit within man's natural kinetic sphere of action, which he asserts is about ten minutes travel time (Doxiadis, 1968). Further, he would build in several forms of travel technology, including foot travel, on a not-to-interfere basis with each other and, of course, in land-use balance with the higher uses of the land for living, recreation, amusement, and business.

Athelstan Spilhaus (1967) also recognizes the importance of thinking small, in urging dispersal to new locations rather than expansion of present centers to accommodate the vast new urban population expected in the next thirty years. He thinks in terms of new cities planned for about a quarter of a million people each, surrounded by something like 40,000 acres or 64 square miles of open land, and kept forever separate by this open land from nearby centers. One begins to envision something like regional or even national zoning as required to assure such schemes.

WHAT'S TO BE DONE

Surely these efforts are on the right track. And surely the engineering and intellectual concepts they embody will be influential in our future development. And surely more are needed. But almost as surely, analysis by a few and acceptance by an elite is not enough. The image of what constitutes a liveable environment must be fixed in the minds of the many and, though aimed at producing healthy societies, the image must be internalized by each of us as a deeply held individual right of universal applicability. We must generate and cultivate an environmental ethic suited to our techno-industrial age, yet meeting the needs of an organism whose environmental response mechanisms evolved over hundreds of thousands of years under very different conditions from those of today. Man is uniquely malleable in his behavior, but there appears to be a foundation of engrained, innate or programmed behavior which he ignores at his peril. The anthropologist, Joseph Campbell (1959-1968), in his magnificent four-volume work on mythology, *The Masks of God,* traces its workings through primitive hunting and agricultural societies to modern times through its two main branches, the oriental and occidental. Common to all is an attempt to develop a group ethic and consequent practices toward the resources of deepest importance to the community that would assure their continued viability and adequate abundance. Societies from earliest times, some predating even the most recent glaciation, seem to have resolved by ritual and myth the conflict between the need to husband and the need to exploit the resources on which they depended. The practical effect of such "cultural" phenomena was to maintain an equilibrium between supply and demand that would be stable and persistent, by mobilizing the deepest psychological forces within people to behave in appropriate ways.

Those forces, say Campbell and others such as Carl Jung, still exist ready for mobilization. But these forces are simply not adequately challenged by either of the two working concepts of modern economics, which is our modern institutionalized or ritualistic way of looking at resources. The environment cannot be treated either as a *commodity* or as a *free good,* or even as some judicious mixture of the two alone, although both concepts have a local, temporary, partial place in the larger goals of better environmental management. But neither such devices as effluent fees by which the polluter is supposed to pay for cleaning up or repairing the effects of an environmental overload, nor public—that is, governmental—ownership of the environmental resource that is to be maintained at taxpayer expense is likely to preserve the environment for long under the continuing pressure of special interest groups for delay or waiver, unless there is at the same time a fundamental, deep underlying conviction that there is a higher ethic than profit and economic growth. This higher ethic must be ecological in nature, owning most simply a driving desire for dynamic equilibrium with the environment and a comprehensive need to return to it, as in payment of a debt, every withdrawal made from it for temporary human use.

The long history of the Wildlife Management Institute and these conferences is witness to the reality of this ethic. Let me encourage you to expect its spread. In January of this year, for example, "An act concerning an environmental policy for Connecticut" was submitted to the General Assembly of the State, resolving "that an official environmental policy for Connecticut be established" and stating, among other things, "this policy will establish certain basic environmental rights of Connecticut's population including the right to clean air and water, to freedom from excessive noises, eyesores, health hazards, or other deleterious influences, and to maintenance of the natural, scenic, historic, and aesthetic qualities of their environment . . . such an environmental policy should include consideration of such factors as water supply, recreation, open space, air pollution, land use, historical, cultural, educational, and aesthetic values, marshlands, floodplain and conservation zoning, refuse disposal, noise abatement, billboard control, control of junked automobiles, fertilizers and pesticides, and petrochemical and thermal pollution" (State of Connecticut, 1969).

I believe the spirit of science, not science itself, gives us a clue to the basic quality we seek in our environment. "Science begins in curiosity and ends in wonder"—in sympathetic, instructive delight and a deepened sense of our own enhanced humanity being at one with the universe.

As Campbell says ". . . civilization . . . is a poetic, supernormal image, conceived like all poetry, in depth, but susceptible to interpretation on various levels. The shallowest minds see in it the local scenery; the deepest, the foreground of the void; and between are all the stages of the way from the ethnic to the elementary idea, the local to the universal being, which is Everyman, as he both knows and is afraid to know."

CONCLUSION

I believe we are seeing the genesis of a new mytho-poetic image of our civilization, that central to that image will be an environmental ethic that strives for man-environment harmony, balance, and conservation in its broadest sense. A fundamental tenet of that ethic will be man's inalienable right, first, to a clean environment and, second, to one that excites his curiosity and moves him to wonder and delight. It is the opportunity and privilege of groups like this assembled here today to help provide the core understanding, knowledge, technology, institutions, and articulation of underlying concepts that will evoke the latent wisdom of our race to transcend itself in meeting the mounting threat of unacceptable waste in whatever form we see around us.

LITERATURE CITED

Brooks, D. L.
1968. A.I.D.C. Journal, Vol. 3 (3) 1.
Brooks, D. L.
1967. BioScience, Vol. 17 (12) 873.
Campbell, J.
1959-68. "The masks of God," Viking Press, N. Y.
Doxiadis, C. A.
1968. Science, Vol. 162 (3851) 326.
Spilhaus, A.
1967. Daedalus, 1129 (Fall).
State of Connecticut
1969. General Assembly, Bill No. 235, January.
Udall, Stewart
1968. 1976: Agenda for tomorrow, Harcourt, Brace and World, Inc., New York.
Weisner, J. B. and H. F. York
1964. Scientific American, Vol. 211 (4) 27.

DISCUSSION

DR. SIMPSON: Thank you, Mr. Brooks. Mr. Brooks has exceeded the ordinary definition of his subject, a clean environment. He has given us a fascinating and sweeping review of all that is involved in our environmental crisis and analyzed the trends as he sees them. He has isolated the future, six different possible futures, gone over them thoroughly, and has asked us to concentrate on everything that is involved in bringing about the kind of environmental ethic which will really guarantee to us the environmental rights that man should enjoy.

I would like to ask Mr. Brooks if he could place in capsule form that coin where right goes over to personal responsibility in connection with a clean environment.

MR. BROOKS: I have a quotation whose source I cannot remember—"Your property rights stop where my nose begins."

DR. SIMPSON: I will simply say that our next speaker has been awaited with great eagerness by all of us. We are fortunate indeed that he is able to come this morning and talk about the plans of his Department. I am sure that many of you read with great interest his statement on pollution curbs in the press a couple of days ago. We are interested in hearing from Secretary Walter J. Hickel, Mr. Secretary.

THE HONORABLE WALTER J. HICKEL: Distinguished guests, ladies and gentlemen, I met with some natural resources people last week, and I want you all to know that our door is always open when we are discussing the problems that confront people such as you represent.

I would also like to say this is a sort of unusual day for the Department of the Interior. During the last month, as you know, we have had birthdays for a couple of famous men, Washington and Lincoln, but today is our birthday. The Department of the Interior is today 120 years old.

You know, you get to wondering what this country would be like if those before us had not had the foresight to put together this Department that in some way, somehow, touches nearly every human being within the framework of our fifty states. Therefore, I think we can congratulate those before us for the wisdom and knowledge and the guidance that they brought forth in connection with this Department.

THE NATIONAL ROLE OF CONSERVATION

WALTER J. HICKEL
Secretary of the Interior, Washington, D. C.

The theme of this Conference, "Conservation in an Urbanizing Society," reminded me of a cartoon I saw in the *New Yorker* magazine.

An affluent couple was getting ready to sit down to dinner on the open-air terrace of their city apartment. The table was set with the first course. The man was lingering over his cocktail, and his wife was saying to him:

"Hurry, dear. Your soup is getting *dirty.*"

That cartoon said a lot about how hard it is these days to enjoy even the simple amenities of life in our polluted urban environment.

It is bad, but in an ironic way, it is good. It's bad because environment has been going downhill for most of our city people, and many in the suburbs, too. It's good because, at long last, enough people have become aware of their environment. Public opinion is ready to *push* in that direction. People are beginning to *give a damn* about environment.

Environment *is* the big conservation challenge of the '70's, which are bearing down on us fast.

The statistics are that 70 percent of the people in the United States live on only about one percent of the land area. In a few decades it will be 80 percent living on 1-1/2 percent of the land. Each year three million more Americans are being shoe-horned into cities that are already filled.

Our national production machinery is humming, but at what price? Oil from offshore pollutes beautiful beaches and endangers marine life; air pollution injures health; pollution from human and industrial waste threatens our major streams; poisonous pesticides and fertilizers contaminate our food; one of the Great Lakes is considered fatally ill.

We cannot turn back the clock. Technology is here to stay. The problem is that we have carelessly assumed that nature can absorb unlimited punishment. Now we are paying the bill.

As I study the diversity and intricacies of the Department of the Interior, I am encouraged at some of the progress of recent years, but it is clearly not enough. We are losing ground.

Five years ago, there was no Federal Water Pollution Control Administration. The control of water pollution, as a federal function, was one of the many diverse duties of the Public Health Service. It is a sure sign of increased public concern when Congress sets up a separate agency, gives it broad new duties and responsibilities, and sharply increases the authorized funds.

Unfortunately, the actual appropriations for this work have not come close to the money authorized.

The Bureau of Outdoor Recreation, another Interior Department agency created during the 1960's, is turning more and more effort toward putting its funds and its studies where the people are. Working with the States and matching their money, the Bureau increasingly handles more requests for central-city swimming pools, urban-area hiking trails and bicycle pathways, vest-pocket parks and the like.

A great national park is a glorious thing, more necessary than ever. But a neighborhood park will have more impact on the lives of the people in that neighborhood who may never have a chance to travel a thousand miles to see a national park.

That is why the National Park Service has in its headquarters a special Office for Urban Affairs, and why it did some real pioneering with its "Summer in the Parks" program in Washington. It explains, too, why the Bureau of Sport Fisheries and Wildlife recently sponsored a program on "Man and Nature in the City," and why it is trying to shape its other activities to meet the needs of city people.

It is quite clear that much of what we call waste is valuable material we have not yet learned how to use economically. Junked automobiles, refrigerators and washing machines contain a wealth of valuable metal, but not in usable form. Mine tailings, which pollute a thousand landscapes, contain treasures never counted in low-grade ores discarded years ago. Noxious substances like sulphur dioxide and fly ash from burning coal can be filtered in smokestacks and put to use in chemical products and building materials.

These are among the environmental projects the Bureau of Mines has undertaken. They suggest some of the ways technology can help us clean up the wastes left behind by careless consumption and inefficiency.

I have cited a few efforts that help, but they are not the *giant steps* we need to make a real impact, to turn this disastrous pollution avalanche around.

Quantity is no longer the problem in America. The *quality* of life is our concern now. It means we must attack the noise, the smoke and fumes, the dirty water, the crowding, the ugliness, the tension and stress.

We still do not know the full consequences of all these evils, but we do know that we cannot afford to wait until all the evidence is in. The soup is getting dirtier.

Last summer I was chairman of the subcommittee which drafted the Republican national platform's section on natural resources and conservation. It said in part:

"An expanding population and increasing material wealth require new public concern for the quality of our environment. Our nation must pursue its activities in harmony with the environment. As we develop our natural resources we must be mindful of our priceless heritage of natural beauty. . . .

". . .We pledge a more energetic control of pollution. . . ."

I know that cynics believe party platforms are dismantled as soon as possible after election and hidden away. But I acknowledge this one with pride. I believe it, and I intend to live by it.

As an Alaskan who was reared in the open country of Kansas, I think it is tragic that any American boy must grow to maturity without learning how to catch a fish or knowing the magic of springtime as it comes across the earth.

We cannot say we are succeeding in urban America as long as this gap exists.

President Nixon has said:

". . .The battle for the quality of the American environment is a battle against neglect, mismanagement, and poor planning, and a piecemeal approach to problems of natural resources. It is a battle which will have to be fought on every level of government, not on a catch-as-catch-can basis, but on a well thought-out strategy of quality which enlists the aid of private industry and private citizens. . . .

". . .Our *single* goal in this field is the *enhancement of the life of every American.*"

The words "natural resources" have a double meaning. There is the material meaning, but even more important is the *psychological* and *spiritual* meaning—*the resources of the heart, mind and soul.*

We need to develop our resources materially, but we also need land free from man's works where one can take a long walk—*alone*—away from the pressures of modern life. The boy sitting on the steps of a ghetto tenement deserves a place where he can discover that the sky is larger than the little hole he can see between the buildings.

We need a high standard of living, but we also need a *high quality of life.* We have the knowledge and the technology to do the job. *Every sign* points to the fact that the American people have the will to do it. The goal of achieving environmental quality is one that is worthy of being the *principal* objective of the *new* Department of the Interior.

DISCUSSION

DR. SIMPSON: Secretary Hickel has indicated he will be happy to answer any questions that you may desire to ask him. Here is a very unusual opportunity. While you are thinking of yours, I will ask one myself.

I read with much interest, sir, your press interview in which you talked about your hope that the conditions in the leases of the oil companies might be revised and toughened. There appeared in the balance of the article to be some interesting legal questions as to whether it is possible to change the rules of the game. I don't know how you would find it, sir, to answer the question, but it is a rather interesting one. Would you care to comment?

SECRETARY HICKEL: I will be glad to discuss that.

In reality, what we did when we said that we were coming up with stricter regulations was to interpret those regulations that are already on the books. We all know that legally one cannot have retroactive rules and regulations, but you can interpret those regulations that existed at the time those leases were given, especially as they pertain to pollution. When we interpreted the regulations and advised the oil companies that they would be absolutely liable or responsible with unlimited liability, we were within the framework of our legal rights, and we so did that.

So far as cancellation of leases is concerned, we do know the oil companies have legitimate contracts with the Federal Government which they paid money for. We are looking into the geological problem to see if we can correct what now exists.

I have already raised the question at the White House on some of these offshore programs of whether the money we will receive will offset possible damage to marine life, natural beauty, public beaches, and private properties. If not, let's not be so anxious to receive that money that we overlook other long-term benefits (Applause)

MAKING BETTER USE OF LAND AND WATER

GLENN E. BENNETT
Executive Director, Atlanta Region Metropolitan Planning Commission, Atlanta, Georgia

I am indeed happy to appear before you at this Conference. The program is most impressive, and it appears to me my role here is to speak as a representative of planning agencies, since I don't see any other planners on the list of speakers. Also, I believe there are only a very few others from the "deep South"; so some references to Georgia may be permissible this morning.

The stifling winter snows of the North and East, the oozing mudslides and floods of the West and Southwest, the deadly oil morass off the coast of Santa Barbara—these devastating reminders from Providence could not have been more tragically timed to bring us face to face with the imminent crisis in our basic resources. Mother Nature has beyond a doubt set the stage this winter for conferences such as this.

I have been asked to consider today what can be done to make better use of land and water, and I am going to interpret this opportunity in what may be a departure from usual planning precepts.

I presume you did not intend for me to list precise steps which ought to be taken in defense of either of these elements. Uses of land and water vary with every creek, every hilltop, every community in the nation.

Nor do I think you intended for me to throw down the gauntlet to any particular branch of government. There are heroes and villains in all of them.

As executive director of the Atlanta Region Metropolitan Planning Commission, I may be somewhat less frustrated than some of my colleagues from more complicated metropolitan areas. I have a different vantage point from which to speak, compared to many of you who are wildlife specialists. My interests are primarily in the organization and management of metropolitan affairs, particularly resources. My topic is broad; it concerns *people* more than *wildlife,* and it gives me an opportunity to review the present *status of public planning* in the country as it relates to some of our conservation problems.

Our agency is the oldest publicly supported regional planning organization in the nation, which may tell something about the good intentions of those who managed public affairs in 1947 when the concept of regional planning was first put forward in the Atlanta area. We've been in business over 20 years, have had some successes, but haven't achieved everything we hoped for by a long shot. It's hard to say how much good a planning agency does. Measurements are difficult.

We suffer, of course, from fragmentation of authority, a condition which is endemic in the United States. In the five-county area which we serve, we have 45 municipalities, 9 school districts, 23 sewer systems, 38 water systems, and several independent authorities.

Every election changes the composition of leadership with whom we must work and whose aspirations we must arouse. Training new mayors and county commissioners is a responsibility of the professional administrators and planners. Democracy is tedious at times. Local elections are frequently excuses for inaction on big public projects.

As Mark Twain wrote, "It takes a long time to prepare a world for man; such a thing is not done in a day!"

Our area has always boasted that its water is the softest and sweetest to be found anywhere, and while this claim has now become more of an echo than a choice, we do have enough potable water for some more growth. For this we are grateful to a couple of mayors and to the Federal Government's Corps of Engineers, who some years ago impounded the rivers to the north of our city, covering hundreds of acres of erstwhile farmlands with a great reservoir of water, called Lake Sidney Lanier.

Georgia has space, a great deal of it, all quite beautifully arranged in mountains and valleys and plains, freshened by lakes, rivers, streams, and the sea coast. Atlanta, which now holds 1,300,000 people in its loose metropolitan embrace, has fewer problems than some cities, ecologically speaking.

I don't mean to suggest to you that we are without urgent problems of misuse of natural resources. We have abused our gifts as flagrantly as anybody else; it is simply that we had more of them to begin with, with less industry and less congestion of population.

We have room to grow and a system of roads with long outreach into areas which are still comparatively rural. This is a dubious advantage, however, since planners don't like to see development go outward in all directions in a helter skelter fashion. This pattern of growth is usually wasteful of land, especially.

A big, rugged mountain, a huge lake, or a stubborn desert is often a better hindrance to uncontrolled scatteration of suburban development than local elected officials who have great difficulty in saying "no" to developers. We waste about thirty percent of our urban land in this country. Much of this could be prevented by better local decisions.

The misuse of land is a monstrous, miserable record ranging from practices which merely annoy to those which threaten our existence. The proper use of land is a disciplined procedure, which requires an understanding of the need, a knowledge of the adaptability of the land, an appreciation of the relative importance of competing needs, and a reasonable plan for development.

A planner friend of mine, Fred Robinson of Harland Bartholomew and Associates, talks a lot about our habitual wrong use of land, the overuse, the misuse, inadequate use, and the unimaginative uses of land in urban areas.

In many cases we build on land not suited to intensive urban development. This may be because of steep topography, poor drainage, unsuitable soil characteristics, or some other reason, but the result is costly and usually undesirable. By this practice we create innumerable problems. We increase flood hazard by impeding flow and by adding to runoff. We encourage erosion by improper grading. We increase costs of development, maintenance and operations. We endanger our water supply and destroy natural amenities. We remove cropland from production and cover up needed raw materials. We eliminate the open space needed to provide "relief" from intensive development and congestion.

After several decades of planning we have not been able to control the timing that would indeed make for better use of land. A planned approach to better use of land would have these three cardinal rules:

1. Land should be made available in urban areas when it is needed. Land is held off the market for a higher price, much of it is often strategic, and there is nothing much we can do to a selfish owner who holds out for a $1,000,000 when his property is on the tax books at $125,000.

   We often hear remarks about "highest use of land"; that is generally thought to be the most productive use. Highest use for whom? Most productive use for whom? The accepted practice is to hold land off the market for the highest and most productive use for the owner! !—More money and more profit for the owner! ! !
2. Premature land development should he prohibited. This wrecks an orderly land use plan, and it produces excessive public service costs which drive poor local governments into bankruptcy and into federal aid. The speculators win and the public loses. Witness the slums of cheap subdivisions on fringes of our cities where little governments are formed without resources for services.
3. Community facilities should be provided when needed and sometimes before they are needed. To locate them after the fact

of growth multiplies the cost and greatly limits opportunity. Sewer systems follow septic tanks at great expense. Big water lines replace small ones, and so on, not to mention roads, police, fire, schools, school buses and the like, all of which should be programmed when land is raw.

It is the function of a regional planning agency to be bold and at times to sound an alarm. Our staff is now trying to sound an alarm about water resources and pollution control. We've recommended a regional authority. So far the response isn't enthusiastic, but we'll see some changed minds when conditions get bad enough. You can always argue against another authority, but if control of natural resources and public facilities related to them isn't region-wide, there is bound to be inefficiency, duplication, and costly chaos. This becomes clearer every year.

Recently my staff, together with well-qualified consulting engineers, produced a long-range water and sewer plan for the eight-county area of the Atlanta region. Population projections are for two-and-a-quarter million people by 1988, three million by 2000, and four-and-a-half by 2020. The most significant finding is that we, in fact, do not have an abundant supply of water to accommodate the growth we are certain to have in twenty years. This is a shock to many of our constituents.

The price tag on future water and sewer facilities is enormous in the Atlanta area alone, which by comparison with the other metropolitan areas in the nation, is twenty-first in population size. The cost of adequate future facilities for all metropolitan areas of the nation is bound to be staggering.

Big events and catastrophes dramatize our mistakes, our bad handling of land and water, but planners worry about the common and more prevalent conditions. These are the less dramatic, slow, gradual, depreciation of land values and living standards. They follow man-made abuses of our resources, particularly of our land.

So we are all aware of the accelerated speed of our environmental degradation. Man has the ability to contaminate the world, and he is proving it every day. We have added more debris and destroyed more natural heritage in the last twenty-five years than had been destroyed in all the earlier years since the beginning of civilization.

For many years the object of city planning has been to meet requirements of people. Nothing has changed this drastically, even though we talk about comprehensive plans and new sophisticated approaches. I would guess that land-use plans over the years have been pretty good. The breakdown has been in performance; they haven't been used. Politicians and decision-makers have favored zoning piece by piece, parcel by parcel, as the pressures increase.

Long-range plans for land use and zoning guides are possible, and they can be workable.

Though it has been noted cynically that we have no real national water or land policies, we actually do have policies and guidelines of every description from broad programs for open space and green lands to precise building codes regulating the construction of the most modest home and plant.

To make better use of land and water in the future, some government reform appears to be required. New mechanisms are needed to bring local, state, and federal laws and regulations into harmony.

Some progress is being made by the multi-jurisdictional areawide organizations being established throughout the country. In Georgia we have 18 multi-county area planning and development commissions. They have come into existence in the past six years or so, and now nearly all of our 159 counties are members of one of these planning and development commissions.

The State supports them financially to the tune of over $800,000 per year, and they do a good job coordinating federal programs. The Soil Conservation Service of the Department of Agriculture works closely with all of these organizations which have planners on their staffs. Conservation programs get better support because of their existence; watershed programs, recreation and open space development schemes are promoted; and soil maps, guides, and descriptions are being used by planners and developers.

Within the past few years we've developed a very close relationship between planners in Georgia and the conservationists, including both the professionals and those citizens who serve on the various land and water resources boards and committees throughout the state. We believe strongly in the importance of maintaining cooperative working arrangements between districts and planning commissions and to this end in Georgia we have formalized the relationships by signed agreements. Most of Georgia counties are now involved. We now have a Georgia Conservancy; and we have some bills in the current session of the Legislature aimed in the proper direction.

The next move would be to make conservation districts and planning districts coterminous. Most of our states are divided into many different districts for many different purposes. If we could only start all over and have fewer divisions, fewer jurisdictions, and a more orderly approach toward statewide problems! In Georgia we don't need 159 counties and over 600 municipalities.

Conservation districts and planning districts, along with Army engineers, Geological Survey people, are pouring out a mass of information in a systematic way so that sound answers, conclusions, and solutions can be found to the land and water problems.

Some time ago my agency published what we believe to be a very valuable publication, entitled, "Soils Interpretation for Regional Planning in Metropolitan Atlanta," in cooperation with the Soil Conservation Service. There has been a heavy demand for this study from private developers, local governmental agencies, and interested citizens. We are now in the process, with the help of the Soil Conservation Service, of making additional interpretations for the soils of the metropolitan area.

We are coming to the time, I hope, when planners and conservationists can have something more than just persuasion as a tool to achieve their best results. As you know, planners and conservationists generally function as advisers. We make recommendations which are often presented on a "take it or leave it" basis.

It would seem logical that before too long, land-use control legislation would have some requirements for soils analysis. We have mandatory review by health officers and engineers for land subdivisions in the more enlightened jurisdictions. Why not mandatory review by soil scientists and conservationists, at least so that they might have an opportunity to indicate to the developer the hazards he might expect? Like many other ideas we have for improvement of our environment, when things get bad enough, something like this will come to pass.

The theme here is "Conservation in an Urbanizing Society." It is an apt and timely title; the emphasis should be on the word, "urbanizing." Soil and water together with the third component—air—determine even the *possibility* of urban life. Management of the urban environment *is* largely soil and water management and the preservation of our air.

Good management of the urban environment is a corollary to good planning. Planning is organizing and analyzing facts, data, and information about land and water. Making the most of it is our concern today.

Planning begins and ends with the human needs of people: air, water, shelter, space, health, education, mobility, work, play—all the factors of life. Prevision of these needs is as intricate, as various, as complicated, as ever-changing and as continuous as life itself. The only limit to our realization of tomorrow will be our doubts of today.

Our goal should be to get the highest and best use of resources for the general welfare of the community, for the public good, and for future citizens. This requires a kind of discipline and public control that we see very little prospects of having any time soon in this country.

Theodore Roosevelt in 1910 said:

> "Every man holds his property subject to the general right of the community to regulate its use to whatever degree the public welfare may require it."

It is easy to say what we ought to have: better public management, more education, and something more subtle than mere education—more perception and vision. We need fewer governments, more consolidation of governments, revised city charters, better zoning laws, and an end to antagonism between cities and suburbia. The theory of taxation needs to be used creatively, to reward and restrain the use of real property. Private enterprise must become more involved in both physical and social planning. There must be less selfishness and less apathy!

Planning must include the stimulation and motivation of elected officials, ordinary citizens, and people who have some special ability to lead and influence others. No planning agency has enough time and money to do this early enough, it seems; we often get to the brink of a crisis before we can come to the point where it's possible to arouse action.

John Gardner has advised us recently that:

> "A nation runs on *motivation,* on *aspiration,* on a *vision* of what it might become. A nation needs challenge. A people has to want something. A people has to believe in something. A nation is held together by shared values, shared beliefs, shared attitudes."

So it is with a community, a region, or a city. A community runs on motivation and aspiration. How do you give people a vision of what they may have? This, I think, is a major responsibility of the planner. The great planners are those who can inspire, those who can create the visions, and those who can make the people listen. A community must believe in its future, its promises, prospects, and its potentials.

As conservationists, planners, and community developers, we must possess a missionary spirit. It takes a certain amount of dedication to work successfully at comprehensive planning and development in a free society. Courage, faith, tenacity, and diligence are essentials for planners.

The amount of public planning that a city, a state, or a region will support over a period of time is surely a measure of the vision of the governments and the people. At the same time the effectiveness of these activities depends almost entirely upon the quality of the leadership. By leadership I refer to the professionals, the businessmen and women, office holders, and citizens.

Galvanized around Georgia Tech's School of Architecture and its Department of City Planning and the new School of Urban Affairs at

Georgia State College, we have in Atlanta a vital group of designers, planners, builders, developers, and social engineers, who see problems as they exist and as they may develop. We talk a lot. Sometimes we planners and professors talk to each other too much, perhaps; we talk too much and accomplish too little.

Our news media are committed to conservation. Their demands for defensive action in development of land and control of water have furnished insistent reminders to leaders as well as arousing citizen response. There are voices on our side, but they are not always listened to with seriousness. Some political leaders are fairly well informed on this subject, and fortunately, we have an effective business power structure who speaks intelligently on behalf of the preservation of the natural elements of the earth. But this isn't enough. Conservation is everybody's business.

Only when there is popular understanding and acceptance can we effectively use land-use controls such as subdivision regulations, zoning ordinances, and landowner agreements.

While our citizens are not universally conditioned to conservation (no person is touchier on the subject of property ownership and individual rights than the Southerner) there is more than common awareness of the need to use our air and space and land and water suitably and carefully. Last year there were, I understand, a record number of successful bond elections for open-space land throughout the country.

More than 400 agencies exist in our nation identifying the problems of the uses of resources. Some of these are nationwide, some regional, some myopically local.

The Georgia State Game and Fish Commission is constantly on the air with radio broadcasts of hunting and fishing conditions throughout the state. The sportsmen may yet save all of us from ruin!

The Federal Government has not only the Departments of Interior; Health, Education and Welfare; Urban Development; Agriculture; Commerce; but dozens of other boards, bureaus, committees, subcommittees, authorities, etc., all concerned with keeping the earth and sky and waters of this hemisphere viable for American residents.

Some admirable surveys and studies have been initiated by governmental action. The 1968 report on the American environment by the President's Council on Recreation and Natural Beauty evaluated prospects and problems in all areas, and included recommendations for cooperative action from government, education, research, and private resources. This study, entitled *From Sea to Shining Sea* also lists books, films, local, state, federal, and private agencies who are available to offer innovative help when they are invited to do so.

Obtaining community action on a regional basis involves the enlistment and support of leaders in all parts of the area. A region has no mayor. A region has no chief county commissioner. A region has no Board of Aldermen. A region is an economic unit in which a great many political jurisdictions exist and where the planning process must function like an octopus, with tenacles reaching out into all jurisdictions.

In every group of which I am a part—everything from civic clubs to professional groups—there is one inexorable solution proposed to every ill: *publicity.* Get the people stirred up! Everything will change if the people demand it.

Which people ??? *Who*??? How??? Why???

Whose work is it to tell an elected official to move to keep an industry from polluting a river? Whose work is it to demand the early setting aside of parklands, or green belts, or simply to save little remnants of land from becoming trash heaps?

The people???

And if one man or two are aroused, is it his or their work to arouse their neighbors to arouse their neighbors? Who is today's Paul Revere, racing from house to house to say that disaster is coming? Perhaps it's a planner! A wildlife expert!

You know the old story about the farmer who banged his mule on the head just to get his attention. I think we are wasting entirely too much valuable time trying to get the attention of 400 million people.

It is my growing conviction that leaders lean far too heavily on what they call the consensus—and that they escape from thinking and acting for themselves by submitting each decision to the informal referendum of the people.

Of course there must be a consensus, or the leaders would not have been elected! Their very selection by the voters is a mandate to act in their behalf!

I think I share with writer William Y. Whyte his somewhat muted optimism about cities and suburbs becoming better as time goes on, because more people will be living in them and *demanding* that they be improved. Mr. Whyte reasons that with more population, leaders will be forced to move in more defensive and protective ways.

But even this is paradoxical. It is as if a staff of qualified doctors were waiting to install modern diagnostic equipment and treatment techniques until their patients discovered that new methods existed elsewhere, while they were dying for lack of them.

Elected officials cannot have it both ways. They cannot be both leaders and followers. Nor can we who are professionals, committed to the responsibility for planning this best of all possible worlds.

The use of land, water, air, space is urgent to the continuation of life. This is the concern of all people everywhere. But the making of rulers and the enforcement of laws rests in the hands of the men and women they have elected and appointed to act in their behalf. The people of the United States have consented to this by their confidence and their votes.

The leaders must lead. And we must help them.

There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success than to take the lead in the introduction of a new order of things!

But this is our task.

DISCUSSION

DR. SIMPSON: I know, as one who listens to all this concern with environmental crises that here is a crisis being stated in very dramatic if not catastrophic terms. People do not hesitate to say that the number one problem in the world today is the problem of war and peace, that the number two problem in all the highly industrialized society of the world today is how to create and preserve a civilized environment which is fit for people to live, work, and play in. As your first speaker this morning indicated so vividly, many of the prospects lying ahead of us are catastrophic prospects. Now, either rhetoric is being abused (which I don't think it is) or the dangers we keep on talking about are real dangers.

Now, my question:—If they are real dangers, how far does one require a real revolution in government before there is some hope of seeing those dangers averted. Running through the last speech was the whole question of persuasion, and also control. Can you rely on typical processes of a democracy or, once given the size of the job to be done, must one undertake a real revolution not only in expectations but in political control?

MR. BENNETT: I believe the problem is large enough that we have to do the latter. In Atlanta we have a saying that if all of the people from the graveyard could come back to town, the only thing they would recognize would be the government. I tell this to other cities, and they seem to agree that that is the case there also.

However, I can think of two revisions of government that have been made in other places, and this may be representative. In Seattle, when a lake was polluted, they initiated a multi-purpose authority, which is something needed in any metropolitan area. Likewise, in Jacksonville, there was consolidation of city and county government after a great deal of corruption in the city government. I have said several times that we could reform the government in Atlanta if we had enough crises and enough corruption. Maybe we had better plan some crises and bring about some corruption.

I don't know how you get people to agree on a major overhaul. However, a lot of people are thinking about it. Politicians are talking openly about that through the back door, but they won't get up on stumps and talk about it.

MR. RALPH BOWLES (New York State Conservation Department): Mr. Bennett, you projected the population growth in the Atlanta area through the year 2020. Also, you mentioned by that time there would be some serious problems arising from this increase in population in water supply, sewage disposal, etc. In the field of wildlife management, we have long had the concept of carrying capacity.

Has any thought been given by your agency that perhaps you should set a maximum human carrying capacity for a given area and prevent population growth beyond a certain limit, which would result in the degrading of the environment?

MR. BENNETT: That is certainly a good question. It has been discussed among planning groups a number of times. Nobody except the planners have the nerve to mention limiting population in different parts of the country. I don't see very much hope for that.

In our case, we are going to be in trouble long before the year 2020, but it is a matter of adopting policies. In this country I do not see any hope very soon of adopting land policies which would really limit the population of certain areas. The Appalachia program, however, is doing something that I think may set the pace for the future. They are designating certain areas in Appalachia where growth should take place. In Georgia a lot of counties are losing population, as they are in a lot of states, especially in the rural areas. However, the objective of every Chamber of Commerce and of most of the people in the area is to figure out new ways to attract people there and to come up with imaginative ideas in relation to tourism that will bring people back. I don't think the country is ready to limit the population but, in the long run, this will have to be done, at least in certain areas.

DR. ROBERT B. WEEDEN (Alaska Department of Fish and Game): I think several people have wondered what kind of revolution there might have to be in government to solve some of our problems. I have heard allusion made to the fact that the resolution would have to be along these lines—that the government would have to free itself from the fetters of individual thought, individual action, consensus on the part of all of us; that the government would have to be free then to act on the basis of advice given by trained professionals in whatever field was necessary.

I would like to go back to the talk made by Mr. Brooks for a moment and say that I see only two catastrophes which to my way of thinking are worthwhile or urgent enough that we should consider this alternative. These two catastrophes are a nuclear catastrophe, and, I believe here the onus of action is already in the hands of government. The second would be the catastrophe of overpopulation, and I would disagree with an implication at least that Mr. Bennett just made—that sometime we might have to think about controlling population in certain areas. I think right now everywhere we have to start thinking about a revolution in government which allows government to start controlling populations on behalf of all its citizens. I think I am reasonably representative of people here in wanting very desperately to retain my own rights as an individual, but I also feel that this is one of those areas where the chances for people to be educated enough to exert control over their own action in this field of population are so remote and the punishment that we as a human race will receive in delaying much longer is so great that we simply have to take more stringent action. I think this must come from the leaders of society almost acting unilaterally to do this. (Applause)

CONSERVATIONISTS MUST DO THE JOB

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

In his inaugural address, President Nixon remarked that the orderly transfer of authority between Administrations offers proof of democracy's enduring quality. Certainly, in contrast to world headlines about repression of fellow humans, free men can be proud that their people-directed systems of government work as they do.

They work well, no doubt, because free men can express their opinions about national matters. They have every right to expect their government to be responsive to their desires.

Many interesting incidents coincided with the passing of power from the old Administration to the new this year, and I trust that the profound significance of one of them did not elude you.

That incident was the spontaneous national outcry about the future of essential conservation programs. Never before, in my experience, has such strong concern been expressed about necessary efforts to restore and protect the quality of the environment. Those political leaders who apparently did not know or care before should know now that many people have a deep concern about their native land.

All the conservation articles and editorials during the past weeks demonstrate that the communications media are alert to—if not publicly committed to—the necessity of conservation. Do you remember how difficult it was only a decade ago to interest more than a handful of dedicated writers and commentators in conservation?

Times change, and we know for sure now that the public can receive a cram course in conservation in a matter of only a few days. Everyone has learned that conservation is an important governmental responsibility—a concept to be followed, a goal to be achieved. Because of this national conservation interest, the Secretary of the Interior, almost overnight, became the best known member of the President's Cabinet.

This conservation awareness did not develop accidentally. It has matured slowly, and it has been broadened progressively in the past decade by the enactment of fundamental conservation programs.

It is difficult and perhaps unfair to designate turning points, but credit is due former Secretary of the Interior Fred Seaton, who succeeded in shining a light into his predecessor's dark tunnel of conservation dispair. And since then, much appreciation is due to President Kennedy, to President and Mrs. Johnson, to Secretaries Udall and Freeman, and to skilled and conscientious men on both sides of the aisle in the United States Congress.

From this talented leadership and capable support there emerged a vastly improved water pollution control program, certainly one of the most urgent and fundamental of all conservation undertakings. There followed an air quality program, an attack on another environmental problem of far-reaching importance.

The Land and Water Conservation Fund gave impetus to outdoor recreation and land acquisition and development. It encourages agencies to think in terms of where they are going instead of where they have been. It has helped Congress to realize that conservation progress requires both authorizations and appropriations. It is pointless to create new programs if funds are not forthcoming to sustain them.

Approval of the all-important Wilderness Act firmly set forth national policy that the selective dedication of unexploited public lands for the enjoyment and study of their natural character is in the country's best interest. The newer concepts of a wild and scenic rivers system and of national trails follow in the same tradition. So, too, in my opinion, do the recent and largely untested enactments that call for an inventory of the pollution of estuaries and recommendations to assure that their great resource potentials will not be destroyed.

This past decade saw the enactment of other basic conservation programs. One is the imperative probing into the implications of the widespread use of pesticides on fish, wildlife, and other of nature's creatures. The sobering scientific facts uncovered by this research are raising serious questions about the well-being of mankind itself. Unlike a decade ago, when there was more apprehension and speculation than fact, there now is no question that some of the chemicals in common use pose grave threats to animal life.

These past few years have seen a commendable growth of man's interest in the welfare of the creatures that inhabit the earth. The Endangered Species Act set protective actions in motion in this country, and the pending legislation dealing with rare animals throughout the world can lead to even greater accomplishments.

Another basic enactment is the Classification and Multiple Use Act, the nearest thing to an organic act for the Bureau of Land Management, the agency responsible for hundreds of million of acres of public lands and the immeasurable resources they contain. Unlike the Internal Revenue Service, which collects revenue rather than generating it, the BLM has an unmatched record of developing new income for our national treasury. Yet previous Administrations and the Congress have forced the BLM to operate on a shoestring.

During this period of political transition there is apprehension and curiosity about the conservation philosophy and attitude of the new

Administration. Not many personal commitments were made to conservation in the campaign, and party platforms invariably offer more rhetoric than substance.

It is on the conservation successes and failures of past Administrations that I urge the new Administration to build its conservation program. I urge it to pursue a truly national and balanced program, not merely a program based on the erroneous notion that the Department of the Interior is a western agency or that only one or two of its activities are of transcending importance.

The same applies to the important conservation programs administered in the Department of Agriculture by the U.S. Forest Service, Soil Conservation Service, and others. The serious business of protecting and improving the quality of the environment should not be shackled by parochial judgment.

I urge the new Administration to accept the recent national outpouring of conservation concern as a directive for progress in overcoming the environmental ills that afflict our land. I urge it to support those basic programs already underway and to develop new ones to meet demonstrated need. I urge the Administration to capitalize on the conservation momentum that already exists.

The federal water pollution control program should be supported without reservation. It should be expanded to deal with oil and thermal pollutants, to regulate discharges from ships and recreational vessels, and to attack acid mine drainage and lake eutrophication. The crucial sewage treatment plant construction grants program, sapped by spending for a tragic and wasteful war and the extravagances of space exploration, operates at only a fraction of its authorized financial horsepower. This program already is a matter of law, but sufficient funds are not being requested to carry it out. Construction costs rise, and the unserviced backlog grows more severe. Only a small part of the $33 billion spent for space projects in this past decade, if invested in sewage plant construction, would have overcome this correctable environment threat.

There are other areas in which to build a responsive and responsible conservation program. Both Congress and the Administration should insist that wilderness designations catch up to the time schedule of the 1964 Act.

The Wilderness Act should be amended so that consideration can be given to unspoiled areas on lands administered by the Bureau of Land Management. It is short-sighted indeed to insist that wilderness exists only on national forests, parks, and wildlife refuges. BLM should be authorized to administer all wilderness and national recreation and other special areas created on its lands.

The Administration and the Congress should seek to make the Bureau of Land Management a resources agency in fact as well as in name. The Administration should reject suggestions that BLM's activities be suspended until the Congress considers the report of the Public Land Law Review Commission. Resource problems on BLM lands need immediate attention. Their correction has been delayed too long already, and public land management should not be frustrated further during the years the Commission's recommendations will be under consideration.

An example of this is the Mining Act of 1872, the antiquated law that surrenders the surface resources of our public land in repayment for the minor scratching that constitutes an acceptable search for sub-surface minerals. That law wastes public resources for the benefit of a few. It interferes with essential resource programs. This hangover from the last century should be replaced by a leasing system that encourages the development of public land mineral resources without impairing other values that are involved.

The new Administration can do many things to construct a positive conservation program. It can require that the various activities of federal agencies be considered with an eye to their impact on private and public land and water resources. The federal highway program exemplifies an activity that can destroy the environment in which people must live and work. While the straight-line concept of highway routing may be less expensive in terms of construction, the cost may be prohibitive in terms of environmental erosion.

Late last year, a recommendation was made to invoke a two-part hearing process so that the public would have an opportunity to comment on highway locations and designs. Highway interests were appalled at the prospect of the people who pay the bills having a voice in determining road location and design. Governors and state road officials saw it as a damper to future highway hopes. Even the incoming Secretary of Transportation, himself a highway man, called the plan an impediment to progress. The changes were approved as policy—not as regulations—on January 17, and I urge the Administration to uphold them.

The conservation challenge of the 1970's does not affect the new Administration alone. Congress also is involved, because only Congress can correct its own deficiencies in organization that frustrate conservation and environmental goals. Committees have overlapping and contradictory functions, and an action by one sometimes offsets the work of another.

The Committees on Public Works, for example, have little understanding of the havoc highway construction can have on human and other resources. The Committees on Agriculture appear insensitive to the effects of stream channeling and drainage on water tables, flood water retardation, and fish, wildlife, and recreation. The Interior and Insular Affairs Committees that pass on national park matters give only passing attention to the national forest programs that occupy the attention of sister committees. The Committee on Merchant Marine and Fisheries authorizes the expenditure of millions for preserving wetlands for migratory waterfowl, and the Agriculture Committees recommend still more millions for wetlands drainage.

New mechanisms and possibly new alignments are needed in both the Executive and Legislative Branches to assure that federal and federally assisted programs meet the test of what is best for the environment. At the same time, it is not enough to say that conservationists stand for something good. We must define environmental goals and measure progress toward achieving them. We must be prepared to act, rather than merely to react.

We lack such a yardstick now, but we must have one if we are to keep pace with the tremendous energies for change and development that persist in this country. We need the help of both the Administration and the Congress to achieve this end. We need a national policy stating that environmental restoration and protection is a desirable objective, an objective that warrants uniform efforts of attainment.

I do not suggest a policy calling futilely for the preservation of a few small areas, but a policy calling for the broadest application of conservation ideals, of which preservation is a part, but not a substitute for conservation. Above all we need a coordination of land and water use. We need assurance that development will be orderly rather than disorderly, that it will be compatible with other resource values, and that what is done contributes to, rather than detracts from, the attainment of a pleasing and productive environment for man.

These are the short-term and the long-range objectives I see for conservationists. One way or another, all of us are engaged in a continuing confrontation with the challenge of population increase, undirected development and massive alteration of the environment. In a collective sense, we are the only conservation army in the field, and we had better recognize this and battle to attain the high ground that must be won.

DISCUSSION

MR. BENNETT: I would like to ask how much contact the Wildlife Management Institute has with planning commissions? I confess I am a little uninformed and that when I received the invitation to come here to speak, I felt the area planners particularly and you people should be closer together. However, how can we do that?

DR. GABRIELSON: I am sure I don't know the entire answer. I am mixed up in community activity also and in one of these coordinated programs. At the present time, if you look this nation over, we have more coordination and more effective action by conservationists at the federal level than we do at the state level and much more in many states at the state level than at the local level. I think it is a matter of communication and of getting men who are interested in big goals also interested in their own neighborhoods. There are enough people in our conservation army so that if each one of them would do a little to stir up the animals in his own community, I think it would be of tremendous help.

MR. DON ALDRICH (Montana Wildlife Federation): Our sportsmen's organizations that are interested in preserving our environment are very fortunate to have dedicated, able people who will give us the guidance we need and get us on the right path on many of these issues. Unfortunately, when we get to the hearing stage, we are also confronted with another battalion of skillful scientists—people who appear against us. I say they are prostituting their knowledge. Now, is there some way that we can reach the people of science so that when they make an appearance they will be speaking a gospel that they know is true?

DR. GABRIELSON: I am sure that so long as human nature is the way it is there will be people who will sell their souls and their integrity for money. I don't know the answer to your question. I unfortunately know some men who have had good scientific training who have done just what you are saying. However, I don't know any way to discredit them except to expose the fact that they are using their knowledge in the wrong way and, of course, this is a very difficult thing to do. It is very difficult to fight a battle, in my opinion, on a personal basis. You have to have the facts on your side as well as the public. Insofar as I am concerned, I would rather have some of the women's organizations on my side than a lot of men's organizations.

DR. SIMPSON: That is a very interesting question, at least from the side of a college president for, if there were a system of accrediting scientists, I would be very interested in applying it. In the academic profession we rely on the judgment of the person, and I think that is a sufficient judgment. The obligation is really upon those who are informed to speak up and correct us.

MR. KEITH OZMORE (Houston, Texas): I have a short comment on the possible way to develop community interest. In my community we are starting an action group in relation to which we are going to make an all-out effort to interest all segments of the population in environmental control programs. We are involving the Negros, the Mexican-American people, organized labor, garden clubs, civic clubs. We are going to try to get them into a talking, active group to work for conservation legislation and programs from the local level to the state. (Applause)

MISS ELEANOR ROBBINS (Laurel, Maryland): How can we keep our national seashores from becoming highways and motels?

DR. SIMPSON: I understand that Congressman Eckhardt has introduced a National Open Beaches Bill. Support that Bill and I think we can keep the beaches for the people. It is H.R.-6656.

Are there further questions? If not, I would like to express my own personal appreciation for the contribution made by the speakers and what I think was an interesting session. I would also like to ask the Vice Chairman to make his comments on the proceedings.

REMARKS OF THE VICE CHAIRMAN

CLIFFORD G. McINTIRE

I consider it a very unusual privilege to share, as vice chairman, in the program this morning. My particular work is that of natural resources director of a national farm organization. The American Farm Bureau Federation, is delighted that the invitation was extended to a general farm organization to participate because while there are a great many dedicated people who have done wonderful work in the field of conservation, we in agriculture are users of land and water. We consider that we have a very important function because about 90 percent of the people of this country have little to worry about in the production of food and fiber and look to the 10 percent to get that job done. You partake of the greatest variety of goods that any country has ever been offered for the smallest proportion of the wage dollar earned of any time in the history of mankind. Therefore, our organization is interested in having a part and playing a good-citizenship role in the issues of conservation.

No segment of the economy using natural resources has done more in conservation of soil and water than has the American farmer and rancher. We have been at it for thirty years, under the early leadership of Dr. Hugh Bennett and the Soil Conservation Service as you now know it. The small watershed program and all the related land-use practices are a part of a long-time conservation effort. We have millions of acres across the country under conservation practices and as you put your priorities in the context of fiscal expenditures by public agencies, I hope that you will not relax in an affluent society and forget that much of the luxury of the room in which you sit, the high quality of the food you will be served at lunch comes out of natural resources in use. Unless enough resources are put into use in a constructive way, these other things we take for granted will not come in quite the same place in the economic equation.

We have a great future. I realize that pressures are intense but I am not forgetting the progress we have made in this country. As I go about the country, I see many changes going on. We need the play of public dialogue. If we want to preserve within the framework of this representative republic the kind of changes which also include opportunities. We want all to express themselves. Let me also say the changes that will take place in the system that we have, even with all of its frustrations, will lead to a better solution than that which could be directed by government order. Now, we all agree that we want change; but on the other hand, we also want proper systems to bring them about. I see no genius in this generation having all the answers for the next generation, but I think we have some answers that we can use to make a far more constructive and livable country for the next generation.

We have had a panel this morning that has challenged our thinking. I am sure each of us will leave here stimulated by the comments of these gentlemen and with the background these men have given us and find that this has been a morning very much worthwhile.

I want to thank Dr. Simpson for chairing this morning's session and to thank each of the panel members and also President Gabrielson for his fine comments. With that, the meeting is adjourned.

-

PART II
TECHNICAL SESSIONS

TECHNICAL SESSION

Monday Morning—March 3

Chairman: LESLIE L. GLASGOW[1]
Professor, School of Forestry and Wildlife Management, Louisiana State University, Baton Rouge

Discussion Leader: FRANK J. SILVA
Chief of Estuarine Studies, Federal Water Pollution Control Administration, Athens, Georgia

---

COASTAL AND MARINE RESOURCES

REMARKS OF THE CHAIRMAN

LESLIE L. GLASGOW

I welcome you to the Conference and especially to this Coastal and Marine Resources Session.

This session is concerned with the long-time neglected area of environment—the coastal zone. The area is important for its high fisheries production. It is important as a fisheries nursery ground. It is important to our waterfowl and to many other birds. It is important for production. It is also very important as a recreation area and an area in which many, many people live. It is extremely important from a mineral production area, especially of oil and sulphur. It is an area of great importance to many people and many interests.

It is also an area of conflict and an area of competition, to which a multiple-use approach must be used.

We have some fine papers this afternoon and, this should be an enjoyable session.

[1]New Assistant Secretary of the Interior for Fish and Wildlife and Parks and Marine Resources, Washington, D. C.

STUDIES OF THE WHISTLING SWAN, 1967-1968[1]

WILLIAM J. L. SLADEN[2]
Johns Hopkins University, Baltimore, Maryland; and

WILLIAM W. COCHRAN
Illinois Natural History Survey, Urbana, Illinois

Over one half of North America's whistling swans (*Cygnus columbianus columbianus*) spend their winter on the estuaries of the Chesapeake Bay and Currituck Sound in Maryland, Virginia, and North Carolina. Winter counts indicate that they are increasing; the estimate in January, 1967, from the Chesapeake Bay alone was over 52,000 birds. The Pacific population winters in small numbers in British Columbia, but mostly in Utah and in the Sacramento Valley, California (Sherwood, 1960).

The whistling swan has been carefully protected for over 70 years. It breeds in the high arctic tundra where man has little influence on its environment. However, over part of its migration route and in its winter quarters it comes into close contact with man.

The population that winters along the Atlantic coast passes through areas, such as Lake Erie, that are highly polluted. Its sojourn in the Cheapeake Bay brings it alongside one of the most rapidly expanding human populations in eastern U.S.A. Very little is as yet known about the speed, or even the routes, of migration across the U.S.A. and Canada to and from their arctic breeding grounds, but they do pass over heavily congested areas of human populations and cross important airline routes. Since the loss of the Viscount airliner in Maryland in 1962 as a result of a collision with swans, there has been a growing awareness of the potential hazard of these swans and other large waterfowl to aircraft.

The Air Force Office of Scientific Research (1966) stresses the need for biological studies of bird movements, as related to migration, nesting, and feeding, as a vital aid to solving the problems of bird/aircraft collisions. The Canadian Wildlife Service suggests certain simple modifications of habitat around airports to make them less attractive to birds (Solman, 1968). We are anxious to find out how we can live in harmony with these bird populations and yet protect ourselves without harming them. With this in mind a program was started in February, 1967, at the instigation of the Canadian Wildlife Service, to study the local and migratory movements of the whistling swan and to gain further understanding of how this magnificent bird fits into the estuarine ecosystem as suggested by Stewart and Manning

[1]Contribution No. 1 of the Chesapeake Bay Center for Field Biology.
[2]Department of Pathobiology

(1958). The headquarters of our operation on the Western Shore of the Bay is the Chesapeake Bay Center for Field Biology[3] between the Rhode and West Rivers south of Annapolis, Maryland. Much of our activities are also on the Eastern Shore between Eastern Neck Island and St. Michaels where some of the largest concentrations of swans spend the winter.

METHODS OF STUDY

(i) *Capture*. During the two winters, 1967-1969, a total of 178 swans were captured; 105 by funnel trap, 17 by cannon net, 53 by drugs, and 3 by miscellaneous methods. The most satisfactory method was the funnel trap, but it could not be used when the Bay froze. The drug method, using a combination of a tranquilizer, Diazepam,[4] mixed in bait with an anaesthetic, alpha-Chloralose (Crider *et al.*, in press) shows great promise for catching large numbers at a time, but it needs further carefully controlled experiments. In their breeding grounds in the Yukon-Kuskokwin Delta (Clarence Rhode National Wildlife Refuge), Alaska, 179 swans were banded by aid of float plane in August, 1968. At the same time Tom Barry (personal communication) of the Canadian Wildlife Service has banded several hundred whistling swans in the Mackenzie and Anderson River deltas, Northwest Territories, Canada. Small numbers have been caught at Bear River National Wildlife Refuge, Utah, and at Shiawaissee National Wildlife Refuge, Michigan.

(ii) *Bands*. Conventional U.S. Fish & Wildlife (FWS) aluminum bands are being used following a protocol established internationally in Antarctica (Sladen *et al.*, 1968) using the left tarsus to indicate birds of known age (*i.e.* banded as cygnets, or in their first winter when the plumage is characteristically grey), and right tarsus for adult-plumaged birds of unknown age. On the opposite tarsus is being placed a conspicuous 1.5 inch (38 mm) tall plastic color band (*white* for Maryland and Virginia; *red* for arctic Canada, and *blue* for Alaska) with 3 large, 7/16 inch (11 mm) numbers and a letter prefix (e.g. *C102*) reading upwards and repeated 5 times around the band. These color bands (Fig 1), with no address, are modified from a design used by Peter Scott, Wildfowl Trust, on Bewick's swans (*Cygnus columbianus bewickii*) in Britain and can be read with field glasses or spotting scope from any position when the swan is standing, upending or swimming away rapidly. It enables us to instantly identify (by the color) the area where banded, and to recognize the bird as an individual (from the reference number)

[3]A collaborative program between the Smithsonian Institution, University of Maryland, and the Johns Hopkins University.
[4]Tranimal of Hoffman-LaRoche, N.J.

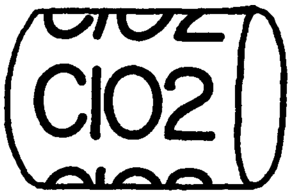


Figure 1.—Color bands are modified from bands used on swans in Britain designed by Peter Scott, Wildfowl Trust. Color bands are blue with prefix A for Alaska-banded swans; red with prefix D for arctic Canada, and white with prefix C for birds banded in Maryland and Virginia.

without further recapture. We attach great importance to the placing of permanent and *individual*-identifying and easily read bands on these birds for future studies on behavior and movements.

(iii) *Dyeing*. Our program is using different combinations of yellow (picric acid) and black or purple (nyanzol) dyes for conspicuous identification in the field. The patterns for the Chesapeake Bay birds (yellow) are such that 4 different local populations can be readily identified. All birds banded at Back Bay, Virginia, are being dyed black. The winter populations are characterized by dye covering the lower half of the neck as well as varying parts of the back and wings; the populations handled in the arctic breeding grounds by dye covering the upper half of the neck only (arctic Canada—yellow; Alaska—black). The birds processed in Maryland and Virginia are held overnight to allow the dye to dry, but this is impossible on the arctic tundra; thus, the dye pattern for the arctic is confined to the top half of the neck, as far away from the water as possible.

A limited number of easily recognized combinations of yellow and black dye on the neck are being used to individually recognize swans carrying telemetry transmitters (see below). These consist of bands of black on the neck dyed yellow, of bands of yellow or of black dye on the undyed white neck. Each of these color combinations can provide 9 easily recognized patterns, so a total of 27 birds carrying transmitters can be recognized conspicuously as individuals.

The dyes do not harm the birds, nor do they appear to affect their winter behavior or family patterns. When the birds molt during the summer the dye is lost, so birds dyed during the winter will regain normal plumage within 5 to 8 months. All dyed birds are metal and color-banded, so subsequent observations are still possible without recapture.

(iv) *Radar tracking*. We consider the dye techniques essentially as a preliminary to more sophisticated methods such as radar and biotelemetry. The swan is proving an ideal subject for radar interpretation, for it migrates in large parties at fairly predictable times of the day, thus producing large echoes on the screen. Speed of flight may also help to differentiate swans from other large birds. We are correlating observations made on the ground with those recorded on radar films and attempting to positively identify swans. These studies are being coordinated by William Gunn of the Canadian Wildlife Service and will be reported by him elsewhere.

(v) *Biotelemetry.* Radar and dyeing are providing data on mass movements and general directions of migrating swans. Biotelemetry is providing data on individual birds. In March, 1968, eight swans were harnessed with transmitters[5] weighing about 90 grams. Portable receiving equipment was used in a truck and an airplane. Ranges obtained from the truck to swans on the water varied from 1½ to 8 miles, the longer ranges being obtained when the truck was at higher elevations. For low-flying swans ranges up to about 15 miles were common, and when the swans flew high (500 feet and up) ranges were 25 to 30 miles. From an airplane ranges of 25 miles were typical.

Swans dyed prior to their spring migration have provided a spectacular number of sight records from five states (Pennsylvania, New York, Michigan, Wisconsin and N. Dakota) and in Canada from ters and harness became covered with feathers, only the whip antenna and occasionally the back of the transmitter were visible.

RESULTS

Sofar we can report 4 birds that were originally banded in the Chesapeake Bay recaptured, 2 in precisely the same trap location, and 2 within 4 miles of it, after one visit to the arctic. Swans dyed on the Eastern Shore of the Bay have been sighted on the Western Shore 10 miles from their original site of capture and Western Shore birds have been seen on the Eastern Shore up to 13 miles away. These sightings have all been prior to migrations as have the ones recorded from birds carrying transmitters (Fig. 2).

Swans dyed prior to their spring migration have provided a spectacular number of sight records from five states (Pennsylvania, New York, Michigan, Wisconsin and N. Dakota) and in Canada from Ontario, Manitoba, Saskatchewan and Northwest Territories. The yellow dye, has proved by far the most effective color for sight records. Of only 15 dyed this color in March, 1968, three were seen resting with several thousand swans on the Susquehanna flats, at the northern end of the Cheapeake Bay, on their way north on March 21, two of them together as paired birds. Four months later, and in their tundra breeding grounds some 3,000 miles away, 3 were also reported by Tom Barry (personal communication) and his colleagues in the

[5]Made by AVM Instrument Company, Champaign, Illinois.

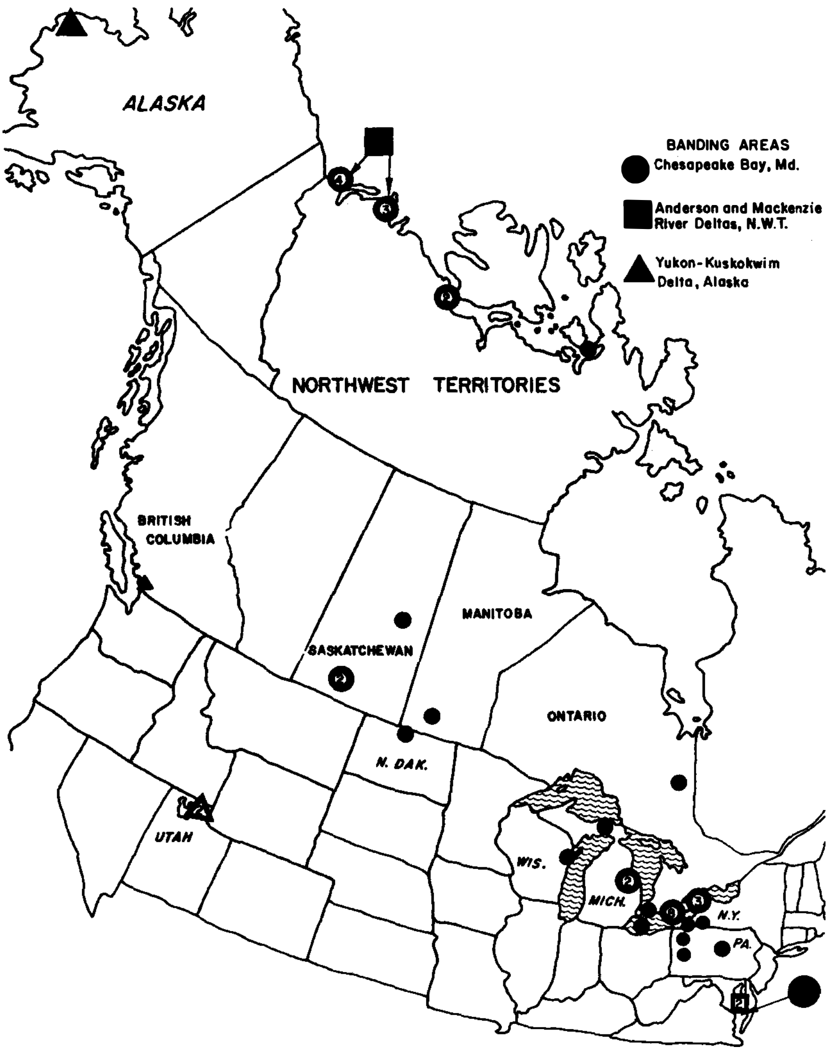


Figure 2.—Sightings or recoveries of dyed and/or color-banded Whistling Swans, 1967-1968. The California recoveries are not included.

Mackenzie and Anderson River deltas, N.W.T. Two of these yellow-dyed swans were side by side and believed nesting. This remarkable sighting-rate of 3 out of 15 (20%) in their breeding grounds demonstrates what excellent study subjects these swans are and how dyeing can be effectively used to define the breeding areas. Figure 2 summarizes the sightings or recoveries so far of dyed and/or color-banded whistling swans and demonstrates that birds marked in the

Chesapeake Bay are breeding along the tundra from the Mackenzie River delta (4 sightings) eastwards to the Anderson River delta (3), Coppermine River (2), and King William Island, Northwest Territories. Only five recoveries have been reported so far from 179 banded (but not dyed) in Alaska in August, 1968. One was found dead in December near Victoria, British Columbia; two were shot in Utah during the November hunting season in Farmington Bay and Bear River National Wildlife Refuge, and two others on November 28 near Sierraville, California.

Results from the 8 birds carrying small transmitters have added further information on local and migratory movements. Swans #1 and #2 were caught at Sherwood Forest on the Severn River north of Annapolis, the others near Claiborne in Eastern Bay. They were all released at Hackett Point at the western end of the Chesapeake Bay Bridge 7 and 14 miles respectively from their sites of capture. Hackett Point is an important pre-migration staging area and for this reason was used as our main tracking station in 1968.

The movements of swan #1 (adult plumage, female) for 10 days after release on March 18 were in the same area and consisted of swimming and feeding with other swans and of occasional short flights. During the next 8 days numerous 7 to 8 mile flights were made between the release area and the trapping area (Figure 3). During the 18 days of observations it was occasionally seen alone, but was usually with 3 to 12 other birds. On April 5 it left Hackett Point, presumably on migration. The flight was north over Baltimore, and the swan outdistanced the truck, which was hampered by evening rush-hour traffic. On April 19, this bird was seen, in apparent good condition at Seney, Michigan.

Swan #3 (juvenile plumage, male), which was displaced 14 miles, flew 8 miles southeast towards its site of capture the day after release. Here, in Eastern Bay, it associated with a small group of other swans at a pre-migration staging area and made no further extensive movements until it migrated on March 31. When this bird took off the truck was northeast of the Baltimore traffic and thus it was followed as far as the Pennsylvania-Maryland border south of Harrisburg (Fig. 3). The average ground speed of swan #3 was 45 mph. It migrated north, carrying it just east of the Baltimore City line. On January 2, 1969, about a year later, this bird was picked up dying near Milford, Delaware. The transmitter and harness were still intact, the young bird presumably having carried it to the arctic and back again. There was a small bare area of thickened skin underneath the transmitter and the bird had only partially molted; otherwise no evidence of harm to the bird could be found. Autopsy revealed a massive infection of heart worm (*Sarconema eurycerca*), which was undoubtedly the cause of death and probably also of the partial molt. This heart infection has been reported as common in Cheapeake Bay whistling swans and other species of swan and geese (Holden and

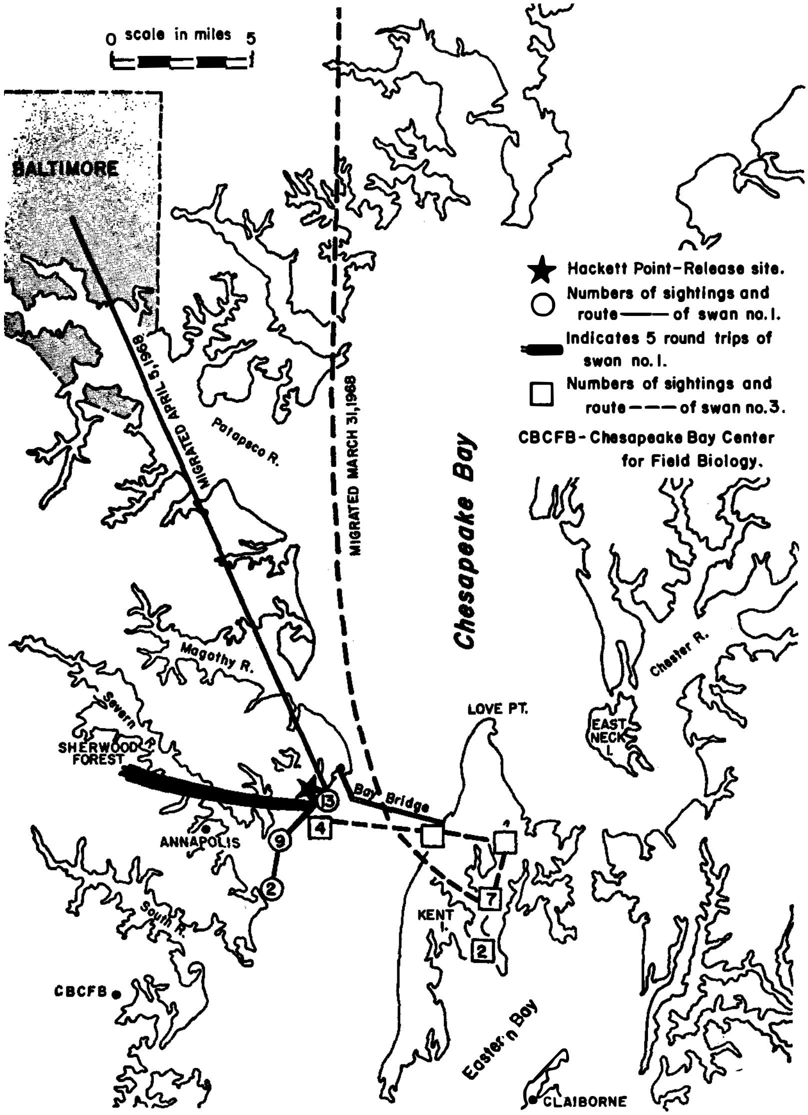


Figure 3.—The local and migratory movements of telemetry transmitter swans #1 and #3 from the Chesapeake Bay.

Sladen, 1968). It is therefore unlikely that the transmitter contributed to the death of the bird.

Further information was gathered on 2 of the remaining 6 swans carrying transmitters. Swan #4 (adult plumage, female) was found dead at Rock Hall about 14 miles northwest of Hackett Point; swan #9 (adult plumage, female) was recaptured alive in good health on March 8, 1969, at Claiborne, Maryland, in the same area where originally captured one year earlier. It had undoubtedly travelled to and from the arctic and lost its transmitter in transit. Further telemetry studies are underway for 1969 and will be reported elsewhere.

DISCUSSION.

Preliminary studies of the whistling swan are showing that this bird could be an ideal model for migratory studies on waterfowl. Preliminary trials with biotelemetry have been able to precisely locate individual birds in their wintering area and track local premigratory movements. One bird was tracked for the first part of its migration from the Bay to Pennsylvania south of Harrisburg. This spring (March, 1969) we hope to track birds at least as far as Lake Erie, Ontario, and gain much-needed information on the number of landings and take-offs and altitude of flight.

Our studies of local movements indicate that the birds are reluctant fliers and when up rarely reach an altitude of 1,000 feet. However, when they take off on their migrations they rapidly attain a much greater altitude. They are certainly not infallible predictors of weather conditions ahead and can become confused, as was the case over Pennsylvania during the third week in March, 1968, when large numbers departed from the Chesapeake Bay under ideal conditions but encountered unfavorable weather as they flew northwest. Swans were reported circling State College, Pennsylvania, during the night in rain or fog and landing in fields or small ponds (Hansblokpoel, personal communication). Some reversed migration and returned to the Chesapeake Bay. These are the conditions we are interested in exploring further so we can better predict the possible hazards to aircraft. There is no reason why we cannot live in harmony with these birds and enjoy the spectacular sights of their winter concentrations so long as we can learn more about their biology and migrations.

ACKNOWLEDGMENTS

We are most grateful to John Moore (Baltimore Zoo), to Vernon Stotts (Maryland Game and Inland Fish), to Walter Crissey, Calvin Lensink, Jim King and other members of the U.S. Fish & Wildlife Service, and to William Emison and Barbara Holden for assistance in the field work; to Elwood Seaman (U.S. Air Force) for good council; and to Charles Kjos, Gene Montgomery and James Bailey (Illinois Natural History Survey) for help in the telemetry work. Many landowners and public citizens have helped in this project, especially Mrs. Ella Burling of Claiborne, Mrs. Spense and Mr. and Mrs. Robert Rich of Hackett Point, Mr. and Mrs. Stuart Janney of Bennett Point, Miss Colhoun and Mr. and Mrs. John Colhoun of Ivy Neck, Thomas Gaudreau of Sherwood Forest, Kim MacKleich of West River, and Peter Thompson of Easton. Financial support has come in part from the Air Force Office of Scientific Research (grant 68-1573), National Science Foundation (GB6680) and the Canadian Wildlife Service. We are also indebted to the Smithsonian Institution Office of Ecology, and Chesapeake Bay Center for Field Biology, the Wildlife Management Institute and the National Audubon Society for support in certain field activities. This is a collaborative program with William Gunn (Canadian Wildlife Service and Canadian National Research Council's Associate Committee on Hazards to Aircraft) and with the Baltimore Zoological Society.

REFERENCES

Air Force Office of Scientific Research
1966. Bird/aircraft collisions. December, 1966. pp. 15.

Crider, E. D., Stotts, V. D. and McDaniel, J. C. (in press)
Diazepam and alphachloralose mixtures to capture waterfowl. 22nd Annual Conference, S.E. Association of Game & Fish Commissioners, Oct. 1968.

Holden, B. L. and Sladen, W. J. L.
1968. Heart Worm, *Sarconema eurycerca*, infection in Whistling Swans, *Cygnus columbianus*, in Chesapeake Bay. Bull. Wildlife Disease Assoc., 4:126-128.

Sherwood, G. A.
1960. The Whistling Swan in the West with particular reference to Great Salt Lake Valley, Utah. Condor, 62:370-377.

Sladen, W. J. L., Wood, R. C. and Monaghan, E. P.
1968. The USARP Bird Banding Program, 1958-1965. in Antarctic Bird Studies. Antarctic Research Series, Vol. 12. Ed. Oliver L. Austin, Amer. Geophysical Union, Washington, D.C. pp. 213-262.

Solman, V. E. F.
1968. Bird control and air safety. Trans. 33rd N. Amer. Wildlife & Natural Resources Conf. Wildlife Management Institute. pp. 328-336.

Stewart, R. E. and Manning, J. H.
1958. Distribution and ecology of Whistling Swans in the Chesapeake Bay region. Auk, 75:203-212.

DISCUSSION

DR. GORDON GUNTER (Gulf Coast Research Laboratory, Mississippi): Have you noticed any social ostracism of any kind of these dye-marked birds?

DR. SLADEN: Our yellow-marked birds and the white birds were fully integrated. Two yellow birds were seen side by side on the breeding grounds. In other words, they probably nested together.

REEF SHELL OR MUDSHELL DREDGING IN COASTAL BAYS AND ITS EFFECT UPON THE ENVIRONMENT

GORDON GUNTER
Gulf Coast Research Laboratory, Ocean Springs, Mississippi

The last Ice Age, called the Würm in Europe and the Wisconsin in North America, lasted over 100,000 years. So much water was tied up in ice that the sea level stood 400 feet lower than it does today and the larger part of the continental shelf was exposed around the Earth.

During that period the rivers along the present Gulf of Mexico coastline were running at a rather steep gradient in gorges or very narrow deep estuaries, possibly into bays and sounds farther out on the shelf. Prof. Albert Collier and I independently found old oyster shells five and ten miles out in the Gulf off the Texas coast. They were quite abundant, and my specimens were taken in trawls. These shells showed signs of having been buried. Emery and Garrison (1967) found oysters as much as sixty miles offshore from the New Jersey coast. They were said to be almost 11,000 years old. It seems certain that estuarine environments formerly lay many miles seaward of what they do now on the Gulf Coast; presumably they moved landward as the sea level rose.

Dr. W. Armstrong Price has recorded oysters [*Crassostrea virginica* (Gmelin)] from corings eighty feet deep in Nueces County, Texas. Presumably, these came from one of the gorges or narrow bays mentioned above. In any case, old mud-covered oysters are not in large reefs or in great abundance below forty feet from the present water surface and generally about thirty feet from the bottom of the bays. This is the situation found in all Gulf States. Apparently, the present bays were formed at that depth.

When the Wisconsin glaciers began to melt approximately 11,000 years ago, the process went on rapidly and sea level rose rapidly to about 12 to 13 feet below the present level 7,000 years ago, the whole change taking 4,500 years or possibly a little less (cf. Scholl, Craighead and Stuiver, 1969). The present bays and sounds were formed at that time, and then the oysters began to proliferate. In fact the age of the bays is best calculated by determining by carbon dating the age of oyster shells from the bottom of the large underground bay deposits. Various estimates made in Mississippi, Texas, and Alabama all agree that the old oyster reefs began at about 6,700 years ago plus or minus 150 years. Most bays are about half filled now (Rainwater, 1964) and, in short, their history is about half over or more.

Naturally, all bays do not fill up at the same rate. The Brazos River of Texas has already filled in its estuary and flows directly into the sea. Since 1932 the Colorado River of Texas has also flowed into the sea, following the blasting of a log jam or "raft," but the bay area is not yet filled on either side of the river. Galveston Bay in most places has about 10 to 12 feet of water and 30 feet of sediment. Apparently, it was about 40 feet deep in the beginning.

Trinity Bay, an arm of Galveston Bay, has filled so rapidly that the process has been noticed by laymen, and not a single reef in that bay lies above the mud, except one that barely comes around the north side of Smith Point at the lower bay margin.

The ultimate fate of all oyster reefs in the bays is to become buried in the mud. Flat low reefs begin to be covered by mud if they are killed out for any reason. I have seen such reefs completely covered in Mississippi Sound in recent years, and I saw Deep Reef in Matagorda Bay similarly destroyed some twenty years ago. Tiger Island, Mad Island, and Dog Island reefs were destroyed in Matagorda Bay in a few weeks time in 1932 when the lower Colorado River course was blasted open. The penned up sediment flowed out quickly and covered reefs which produced one-fourth of the annual Texas oyster crop at that time.

The Point au Fer Reef off the mouth of the Atchafalaya River in Louisiana was thirty miles long and was probably the largest oyster reef on Earth in recent times. It is now covered with mud. Similar processes are going on in all Gulf coastal bays, with the exception of Barataria and Caminada bays in Louisiana, which lost their main sediment source when levees were placed along the lower Mississippi River (Gunter 1952). The obliteration of the bays by filling with sediment from land is a natural geological process. It has been going on for more than six thousand years, and it will continue. Man can hurry up this development or cause it to take place at a slower rate, but in the long run he cannot stop it.

Along most of the Gulf Coast man has probably increased the rate of the sedimentation of the bays in the past 100 years by the clearing of land and the cutting away of the vegetation cover, which causes more sediments to flow into the rivers, and by navigation projects which have brought about the straightening and deepening of various streams. According to Judson (1968, p. 370) the total material delivered annually to the sea by the rivers of the whole Earth is now about 2.6 times (24×10^3 metric tons) what it was "before man started tampering with the landscape on a large scale." Counter-actions to this development have been reservoirs built along various streams. These act as sediment traps and retard bay filling until such time as they become full. Then probably more sediment than ever will be released into the bays at a faster rate.

When the bays were formed originally they consisted essentially of basins and apparently were as deep inland next to the river mouths as they were next to the seaward passes. Salt water came in along the bottom and mixed with the fresh water forming a salinity proper for oysters, thus enabling large oyster reefs to develop not too far from the rivers. Mobile Bay is a case in point. The large deep deposits of shell there, which is called mudshell because it comes out of the mud, were probably covered before the Christian era. As the mud slowly filled in, the upper bay areas became marsh or at least became much shallower. The geologists have a term for this, called progradation of the delta. As a result, the water volume of the upper bay became so small it was then dominated by river water and became lower in salinity than oysters could tolerate; thus the oyster reefs were killed out in the upper bay, and only survived nearer the sea. In effect the live oyster reefs moved down the bay. Today the commercial oyster production in Mobile Bay is only in the lower one-fourth of the bay, and oysters live only in the lower one-third. The buried reefs cover a much greater area than the surface reefs. This is shown clearly by Figure 1, taken from Ryan (1967), which shows a transect of Mobile Bay from the head to where live reefs are found. The upper live reefs are being inexorably covered by mud, a process which anyone can see for themselves in late winter or early spring when the river flow is at a peak. Mobile Bay covers 392 square miles or 250,880 acres. According to Ryan (1967) about four tons of sediment per acre of bay bottom enters the bay every year.

Trinity Bay, a branch of the Galveston Bay system, is another example. People now living remember when it produced oysters, but today it is a very muddy, shallow, low-salinity area. When I was marine biologist for the Texas Game and Fish Commission I was shocked one time when fresh-water commercial fishermen applied for a permit to catch fresh-water catfish and buffalo in this large bay.

At the present time no oysters are produced north of Todd's Dump on the west side of Galveston Bay, although there are some scattered reefs north of that area. From Eagle Point on the west side of

BURIED OYSTER REEF ZONES
SCHEMATIC CROSS SECTION FROM COMBINED LONGITUDINAL PROFILES

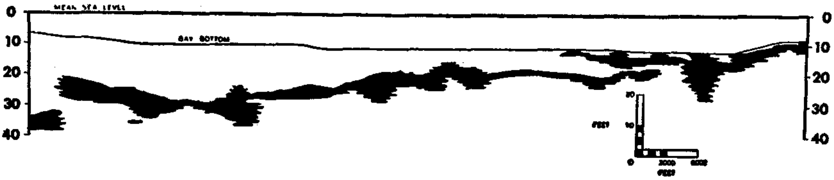


Figure 1.—From Ryan (1967).

Galveston Bay, the Redfish Reef area, extending across to Smith's Point on the eastern shore, marks the northern part of oyster production in the bay.

THE OYSTER AND SHELL RESOURCES ALONG THE GULF COAST OF THE UNITED STATES

As oysters lived thousands of years ago and as they do now in the lower bays, in their never-ceasing process of growing upward faster than the encroaching sediment was deposited around them, they formed large thick reefs. I pointed out that the formation of massive reefs is a characteristic of *Crassostrea,* in contrast to *Ostrea,* and that this constitutes one of the differences between the genera (Gunter, 1950).

Some of these reefs come to the surface and still have live oysters on them bearing the relationship of a skin of living material on a large body of dead material (Figure 2). One can calculate how fast these oysters have grown upward with carbon dating of the lower shell. The length of time involved and the depth of the deposit shows how fast oysters grew upward. If the reef started at a base level of 30 feet below the present bottom, the rate of growth upward has been 1.4 mm. a year for about 6700 years. We have no reefs starting from the base level and breaking to the surface, but a reef shown in Figure 2 would have grown upward at about the same rate a year, assuming that it began 4470 years ago. These remarks apply to the growth rate of a reef upward, which for various reasons is not nearly so fast as the growth rate of an oyster, which under prime conditions may be as much as 0.33 mm a day (Gunter, 1951).

Maps of mudshell deposits in the bays are so complicated that they are almost meaningless. The oyster shells are found at various depths down to 32 feet below the bay bottom and at various thicknesses. Deposits less than two feet thick are not workable by shell dredges. Studies of the deposits of dead reef oyster shell have not been made in all Gulf States, and the best estimate of the resource can be derived from the production figures.

(1) Mudshell Production by States

Dead reef shell is dredged in considerable quantities in Florida, but we have no figures for that state.

Mudshell has been produced in Alabama since 1871. The figures are given in Table 1. An average of 4,204,306 cubic yards of shell per year was produced from 1871 to 1968. A total of 412,022,000 cubic yards of shell have been removed from Mobile Bay during that period of 98 years.

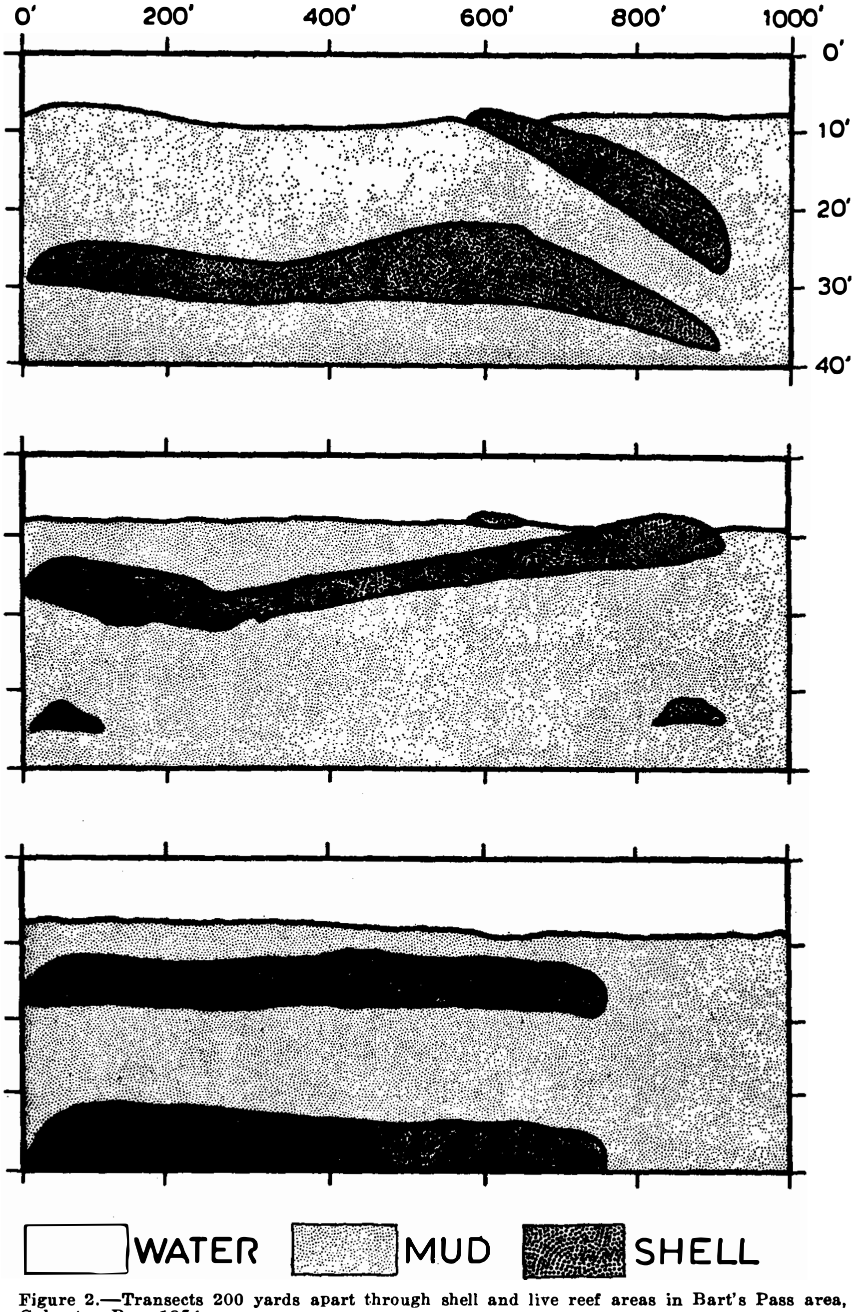


Figure 2.—Transects 200 yards apart through shell and live reef areas in Bart's Pass area, Galveston Bay, 1954.

TABLE 1. THE ANNUAL DEAD REEF OR MUDSHELL PRODUCTION OF ALABAMA (MOBILE BAY) IN THOUSANDS OF CUBIC YARDS TAKEN FROM ALL KNOWN RECORDS, BY COURTESY OF KENNETH R. McLAIN, RADCLIFF MATERIALS, INC.

1871—	39	1896—	1,755	1921—	3,144	1946—	3,623
1872—	108	1897—	1,532	1922—	6,103	1947—	1,290
1873—	163	1898—	498	1923—	6,833	1948—	9,549
1874—	165	1899—	315	1924—	4,664	1949—	6,315
1875—	354	1900—	4,273	1925—	6,637	1950—	6,657
1876—	221	1901—	3,638	1926—	10,966	1951—	3,241
1877—	46	1902—	0	1927—	12,505	1952—	3,959
1878—	0	1903—	2,410	1928—	9,317	1953—	5,023
1879—	0	1904—	2,410	1929—	6,383	1954—	1,011
1880—	0	1905—	500	1930—	4,944	1955—	3,776
1881—	0	1906—	868	1931—	9,523	1956—	10,046
1882—	1,316	1907—	1,109	1932—	6,957	1957—	28,139
1883—	1,138	1908—	3,165	1933—	11,096	1958—	0
1884—	3,224	1909—	2,169	1934—	4,023	1959—	23
1885—	1,297	1910—	350	1935—	5,813	1960—	1,828
1886—	624	1911—	2,627	1936—	4,454	1961—	7,145
1887—	830	1912—	9,101	1937—	2,441	1962—	11,035
1888—	830	1913—	7,676	1938—	3,149	1963—	411
1889—	0	1914—	6,149	1939—	6,193	1964—	14,415
1890—	887	1915—	4,407	1940—	4,458	1965—	13,069
1891—	897	1916—	4,668	1941—	10,342	1966—	5,778
1892—	2,560	1917—	2,714	1942—	2,514	1967—	5,660
1893—	2,459	1918—	2,706	1943—	4,079	1968—	5,628
1894—	5,324	1919—	5,406	1944—	7,606		
1895—	6,852	1920—	6,259	1945—	3,678	TOTAL	412,022,000

If four tons of sediment are laid down in Mobile Bay every year for each acre of bay bottom, as suggested by Ryan (*op. cit.*), and the sediment weighs 2700 pounds to the cubic yard, then approximately 753,000 cubic yards of sediment is deposited in the bay each year. That would mean that the rate of shell removal, 412,022,000 cubic yards in 98 years, has been about 5.5 times as fast as the deposition of sediment. Looked at another way, this means that shell dredging has prolonged the life of Mobile Bay about 440 years.

Unfortunately, Mississippi has only small mudshell deposits, and we wish that we had one of the large reefs like Hanna's Reef in Galveston Bay to dig up. We would put mudshell dredges on it right away and and build much larger live oyster beds than existed on that reef with the use of the shell, and we would sell a great deal of the shell to industry. This would bring howls of anguish from so-called conservationists who think there is some intrinsic value in an old dead reef, which will never recover and which is destined only to become covered with mud.

So far as the record goes, the first mudshell was dredged in Missisippi in 1951. The amounts dredged are not available between 1951 and 1953, but the production was less than 1,000,000 cubic yards. From 1954 to 1961, inclusive, 1,473,000 cubic yards of shell were dredged, and from 1962 to 1969, the amount was 1,633,000 cubic yards. The total in eighteen years has been about one-fourth of what Mobile Bay has produced in one year and only one-half of what the Galveston Bay system has produced in one year. Mississippi is not an important mudshell-producing state. That form of wealth has fallen mostly to other states.

According to Biennial Reports of the Louisiana Department of Conservation and later the Wild Life and Fisheries Commission, dead reef shell was not taken in large quantities there until the mid-thirties following the establishment of chemical plants which needed the shell. The first Louisiana records of mudshell production began with 1936. Both oyster shell (*Crassostrea virginica*) and clam shell (*Rangia cuneata*) are dredged in Louisiana. The production figures are given in Table 2.

The shell production of Texas is given in Table 3. These figures were obtained from the Texas Parks and Wildlife Department. The mudshell industry of Texas started in Galveston Bay in 1880, when men rolled wheelbarrows on planks from shore to dead reefs and shoveled up the shell by hand. Production records for the early years are missing, and they begin with the fiscal year 1922-23. Since that time Texas has produced 270,335,000 cubic yards of shell and Alabama has produced 296,491,000 cubic yards. Alabama's production all came from Mobile Bay, and the greater part of Texas' production, about 80 percent, has come from Galveston Bay, although separate bay figures for Texas are not available before 1959.

For the last year that we have records for all the states, 1965, Alabama, Mississippi, Louisiana and Texas produced 28,730,000 cubic yards of mudshell worth about $86,000,000.

(2) The Oyster Resources

The oyster production of the four states under consideration is given in Table 4. The figures from 1880 to 1945, inclusive, are taken from Gunter (1949), and the figures from 1948 to 1965 are taken from

TABLE 2. THE SHELL PRODUCTION IN CUBIC YARDS OF THE STATE OF LOUISIANA FOR VARIOUS YEARS.

	Oyster Shell	Clam Shell
1936	727,222	251,779
1937	741,640	145,737
1944	1,085,690	544,366
1945	976,477	652,122
1946	763,501	724,224
1947	918,980	954,311
1952	1,642,995	2,054,927
1953	584,366	1,506,633
1956	2,287,130	2,701,362
1957	2,256,665	3,994,118
1958	3,083,556	3,814,645
1959	2,901,967	4,032,026
1960	2,540,383	3,562,799
1961	2,196,994	3,297,591
1962	4,089,291	2,827,501
1963	4,243,379	2,953,222
1964	3,968,226	4,031,095
1965	4,332,607	4,770,364
Totals	40,342,069	42,818,822

TABLE 3. THE DEAD REEF SHELL PRODUCTION OF TEXAS, IN CUBIC YARDS, BY COURTESY OF MR. T. R. LEARY, TEXAS PARKS AND WILDLIFE DEPARTMENT. SCHEDULE OF SHELL PRODUCTION IN CUBIC YARDS FOR YEARS ENDING AUGUST 31

Years	Total Shell Production	Years	Total Shell Production
1922–23	829,390	1944–45	3,455,799
1923–24	1,212,876	1945–46	4,500,259
1924–25	1,205,490	1946–47	5,482,190
1925–26	1,951,834	1947–48	6,227,922
1926–27	1,982,745	1948–49	7,174,295
1927–28	1,705,093	1949–50	7,526,739
1928–29	1,772,650	1950–51	3,461,670
1929–30	1,750,345	1951–52	9,159,071
1930–31	1,522,017	1952–53	10,029,799
1931–32	1,185,814	1953–54	10,823,181
1932–33	537,897	1854–55	10,095,025
1933–34	767,773	1955–56	11,366,018
1934–35	807,610	1956–57	12,043,378
1935–36	1,628,069	1957–58	11,470,112
1936–37	2,204,625	1958–59	11,296,422
1937–38	2,146,721	1959–60	11,449,396
1938–39	2,255,651	1960–61	11,701,385
1939–40	2,101,783	1961–62	12,130,867
1940–41	3,485,016	1962–63	11,533,766
1941–42	5,195,832	1963–64	11,752,878
1942–43	5,485,578	1964–65	12,094,964
1943–44	4,698,885	1965–66	11,547,690
		1966–67	12,678,080

federal statistics (Lyles, 1967). For the last year of complete record the four states produced 1,257,000 gallons of oysters worth retail about $10.00 a gallon. At this figure the worth of the oyster crop was $12,570,000.00.

The total oyster production for the Gulf States since 1880 comes out to over one billion pounds, if we include a factor for the years in which there are no data, based on average production of the years surrounding the missing years, and if we include the years after 1965. All of these states are mudshell producers, and the two largest producers, Alabama and Texas, started shell operations in 1871 and 1880.

In the same manner it can be shown that these states have produced approximately one billion cubic yards of mudshell since 1871 and some 20 billion pounds of fish, crustaceans and mollusks, including oysters.

SOME RELATIONSHIPS OF MUDSHELL, OYSTER AND FISHERIES PRODUCTION

Table 5 shows the average shell, oyster and total fisheries products for the Gulf States, not including west Florida, from 1959 to 1965 was greater annually than in the period 1949 to 1958. After a high in oysters from 1902 to 1945 and a low period from 1946 to 1958, the oyster production has been rising to peak levels as the mudshell industry does the same thing.

TABLE 4. OYSTER PRODUCTION IN POUNDS IN ALABAMA, MISSISSIPPI, LOUISIANA AND TEXAS FROM 1880 TO THE PRESENT. THE FIGURES FROM 1880 TO 1945 ARE TAKEN FROM GUNTER (1949) AND THE LATER YEARS ARE TAKEN FROM LYLES (1967).

Year	Alabama	Mississippi	Louisiana	Texas
1880	731,500	175,000	2,065,000	469,378
1887		4,067,700	4,747,589	1,793,393
1888	532,875	5,370,435	5,039,944	2,388,925
1889	3,068,975	5,918,521	5,848,640	2,524,200
1890	3,367,490	5,645,346	5,891,095	3,085,600
1897	1,785,438	4,407,992	6,714,330	2,491,370
1902	2,432,222	16,835,924	8,388,891	2,401,791
1908	4,132,000	7,473,900	25,553,000	3,481,000
1911	3,093,419	4,603,690	31,530,814	3,042,830
1918	1,031,891	4,040,652	12,800,242	3,265,738
1923	2,261,602	4,731,636	14,298,081	2,519,846
1927	1,164,737	18,807,711	11,541,223	2,762,879
1928	4,218,123	7,458,493	18,599,791	1,807,631
1929	399,924	8,126,952	18,445,199	2,500,743
1930	286,794	2,324,700	7,307,846	1,157,315
1931	768,721	1,637,491	5,390,211	982,332
1932	859,217	5,222,320	2,978,061	980,601
1934	391,800	298,100	10,197,500	1,311,800
1936	991,800	1,705,000	9,808,700	823,100
1937	1,235,200	4,501,700	16,440,500	1,189,600
1938	1,358,700	2,241,400	10,222,300	1,355,900
1939	1,357,100	7,706,400	13,586,400	987,300
1940	936,000	2,270,100	12,412,200	1,297,200
1945	1,605,700	265,200	9,884,010	718,800
1948	1,531,000	1,309,000	9,016,000	579,000
1949	1,586,000	462,000	9,688,000	299,000
1950	2,070,000	508,000	8,718,000	125,000
1951	2,191,000	27,000	8,164,000	456,000
1952	1,842,900	23,000	11,402,000	828,000
1953	1,450,000	318,000	9,345,000	1,069,000
1954	739,000	977,000	8,361,000	699,000
1955	1,581,000	1,731,000	9,936,000	543,000
1956	769,000	846,000	10,056,000	985,000
1957	1,291,000	863,000	10,490,000	953,000
1958	458,000	579,000	8,265,000	311,000
1959	895,000	333,000	9,667,000	1,411,000
1960	1,169,000	2,391,000	8,311,000	2,296,000
1961	509,000	3,241,000	10,139,000	1,096,000
1962	443,000	2,073,000	10,160,000	1,210,000
1963	995,000	4,680,000	11,563,000	2,618,000
1964	1,005,000	4,829,000	11,401,000	3,357,000
1965	493,000	2,969,000	8,343,000	4,835,000

TABLE 5. THE AVERAGE ANNUAL DEAD SHELL PRODUCTION, OYSTER PRODUCTION AND TOTAL FISHERIES PRODUCTION OF ALL GULF STATES, WITH THE EXCEPTION OF FLORIDA, FOR THE PERIODS SHOWN, IN THOUSANDS OF CUBIC YARDS AND THOUSANDS OF POUNDS.

Years Inclusive	Dead Shell	Oysters	Fishery Products
1948–58	17,517	11,299	376,509
1959–65	22,346	15,980	1,216,233

Oysters should be very sensitive to any deleterious effects of dead-shell dredging because they are non-motile and easily covered vith sediment. Furthermore, they are subject to being dug up, also, because of their non-motility. Therefore, the relationship between dead shell production was tested statistically by using the figures shown in Table 6 to determine the coefficient of correlation between shell dredging and oyster production. There are 39 degrees of freedom and r = 0.532, which is significant at the 1 percent level. States in

TABLE 6. THE DEAD REEF OYSTER SHELL, THE OYSTER PRODUCTION AND THE TOTAL FISHERIES PRODUCTS FOR ALL STATES WHERE SHELL WAS DREDGED AND FISHERY RECORDS WERE KEPT ARE SHOWN SINCE 1880. ONLY ALABAMA FIGURES ARE GIVEN FROM 1880 TO 1918; TEXAS CAME IN AT 1923, LOUISIANA IN 1936 AND MISSISSIPPI IN 1954. SHELL IS IN THOUSANDS OF CUBIC YARDS AND OYSTERS AND FISHERY PRODUCTS ARE IN THOUSANDS OF POUNDS.

Years	Dead Shell	Oysters	Total Fishery Products
1880	0	732	3,542
1888	0	533	1,634
1889	1,426	3,069	4,560
1890	887	3,367	4,777
1897	1,532	1,785	4,699
1902	0	2,432	9,351
1908	3,165	4,132	10,665
1911	2,627	3,093	—
1918	2,706	1,032	5,609
1923	7,662	4,782	27,191
1927	14,488	5,281	31,159
1928	11,022	6,026	29,678
1929	8,156	2,811	25,649
1930	6,694	1,444	22,806
1931	11,045	1,751	25,219
1932	8,143	1,840	20,410
1934	4,791	1,704	25,392
1936	6,809	11,624	99,787
1937	5,388	18,866	131,468
1938	5,296	2,715	35,761
1939	8,449	2,344	26,545
1940	6,560	2,233	30,713
1945	8,111	12,209	183,717
1948	15,777	2,110	68,136
1949	13,309	1,885	89,686
1950	14,184	2,195	108,239
1951	6,708	2,647	11,9331
1952	14,761	14,072	520,887
1953	15,637	11,954	564,863
1954	12,018	2,415	288,841
1955	14,055	3,855	331,929
1956	23,883	12,656	792,180
1957	42,623	13,597	582,658
1958	14,738	9,613	682,252
1959	14,405	12,306	1,023,064
1960	16,001	14,167	1,130,415
1961	22,226	14,985	1,251,722
1962	27,459	13,886	1,317,803
1963	16,392	19,856	1,274,829
1964	30,340	20,592	1,188,175
1965	29,701	16,367	1,327,609

which dead shell dredging was not yet introduced were not used, of course, nor were the years used when either shell or oyster production was not shown.

The writer has shown (Gunter, 1967) that the commercial fisheries catch of the Gulf of Mexico is made up of about 98.2 percent estuarine species, if we include the species which are raised in the bays and thus are essentially tied to the bays at young stages, even though they may be caught as adults in offshore waters. In any case, most Gulf fishery species are highly dependent on the estuaries and the healthful condition of estuarine waters. Anything harmful to the estuaries would bring about a general decline in total fisheries production. But the opposite is the case. The Gulf fisheries are flourishing, and they now produce about 30 percent of the total catch of the United States.

The dead-shell production of the four states considered shows a coefficient of correlation with the fishery production as shown in Table 6 from 1880 to 1965; with 38 degrees of freedom $r = 0.488$ which is significant at the 1 percent level.

Although there are ways that the mudshell industry can increase oyster production, and ways that it has done so without trying, and although some oyster biologists maintain that shell dredging is beneficial to the bays (cf. Ingle, 1964), it is scarcely probable that the apparently strong correlation between oyster and fishery production with mudshell production is real. It is more reasonable to assume that increased population, better technology and increased need brought about simultaneously better use and more intensive exploitation of Gulf Coast resources and a parallel production of dead-shell and fishery products. The significance of these figures is that they are the strongest possible proof that the dead-shell dredging is not harmful to marine life and has not been for the 98 years that the fishery and shell dredging have prospered side by side.

There are other indications that mudshell dredging and the oyster industry can get along together very well. Personnel of the Gulf Coast Research Laboratory and the Mississippi Marine Conservation Commission took over management of the oyster reefs of the State of Mississippi in 1960. A comparison of the oyster production from 1934 to 1959 and the production from 1960 through 1968 shows that the annual oyster production has increased 3.5 times during the latter period. The state figures show that the 1960 to 1968 production as compared with the twenty years previously is 4.5 times as great a year. These are based upon production measured in Mississippi barrels. The use of federal statistics which are in pounds of oyster meats produced show that from 1960 to '68, inclusive, the annual production is 5.1 times what it was in the previous twenty years. During this latter period Mississippi has produced dead reef shell at a greater rate than ever before and, in fact, this production has been utilized to enhance the oyster industry.

In a very brief note published in Proceedings of the Texas Academy of Science in 1938, I showed that mudshell made a fine cultch for oysters. Shucked oyster shells are relatively rare and hard to come by and, furthermore, they quickly become slimy in the water due to bacterial and algal growth on the surfaces because the organic material has not been leached out. This organic slime interferes with setting of the oyster larvae. At the present time mudshell is used as cultch by the States of Florida, Mississippi and Louisiana in the management programs of state oyster reefs. The shell is now towed out on barges and jetted overboard with high-powered fire hoses.

Figure 3 shows photographs of this process in Louisiana. Mississippi started with 3200 acres of oyster reefs in 1960. Today we have 7,000 acres of oyster bottoms, 1,760 of which were made from mudshell plantings. Figure 4 is a diagrammatic drawing of a reef in one of our most productive areas. In this area approximately 1200 acres of bottom were planted in mudshell.

The Mississippi oyster production has not reached the peaks that were obtained from 1902 to 1929. However, over one-fourth of the oyster acreage is closed down due to sewage pollution and it may be that the potential production is as high as it ever was.

Louisiana, which is quite a large producer of oyster shell and clam shell, which are both dredged from the bay bottoms, produces more fishery products than any state in the Union. In Galveston Bay the oyster production has been higher during the last nine years than it has ever been before, and the production of other seafoods also has been high. From 1953 to 1967 the mudshell production of Galveston Bay has been at an all time high and ranged from 7,240,000 cubic yards to 9,635,000 a year. Fairly heavy dredging in this area has gone on since 1950 when the production was almost 7,000,000 cubic yards a year. Even so the production of fishes, crabs, oysters, and shrimp grew to unprecedented levels in 1959 to 1967, and during the period 1964 to 1967 they increased remarkably. These facts are shown in Table 7. The figures were furnished by Mr. George Snow of the U.S. Bureau of Commercial Fisheries of New Orleans, Louisiana.

One of the most productive oyster areas in recent years in Galveston Bay is called the A Lease. This is an area which was drilled for oil by the Humble Company just north of the former Redfish Reef and many of the wells were productive. The oil company found that it was best to build a "pad" of mudshell, a few hundred feet in diameter, and then put their drilling rig on top of that. In some cases the total works were removed when dry holes were found, and in others when the rig was removed most of the area was left open around the well.

TABLE 7. THE COMMERCIAL FISHERY PRODUCTION OF GALVESTON BAY 1959 TO 1967 IN THOUSANDS OF POUNDS, COURTESY OF GEORGE W. SNOW, U. S. BUREAU OF COMMERCIAL FISHERIES, NEW ORLEANS, LOUISIANA. OYSTERS ARE IN POUNDS OF MEAT; THE OTHERS ARE TOTAL WEIGHT AS CAUGHT.

Year	Fish	Crabs	Oysters	Shrimp
1959	64	108	556	600
1960	44	102	1,163	1,647
1961	125	129	383	1,284
1962	161	311	750	4,193
1963	219	978	2,131	3,628
1964	498	1,196	2,921	5,418
1965	876	1,818	4,584	4,198
1966	593	1,358	4,083	1,941
1967	768	1,048	2,993	2,187

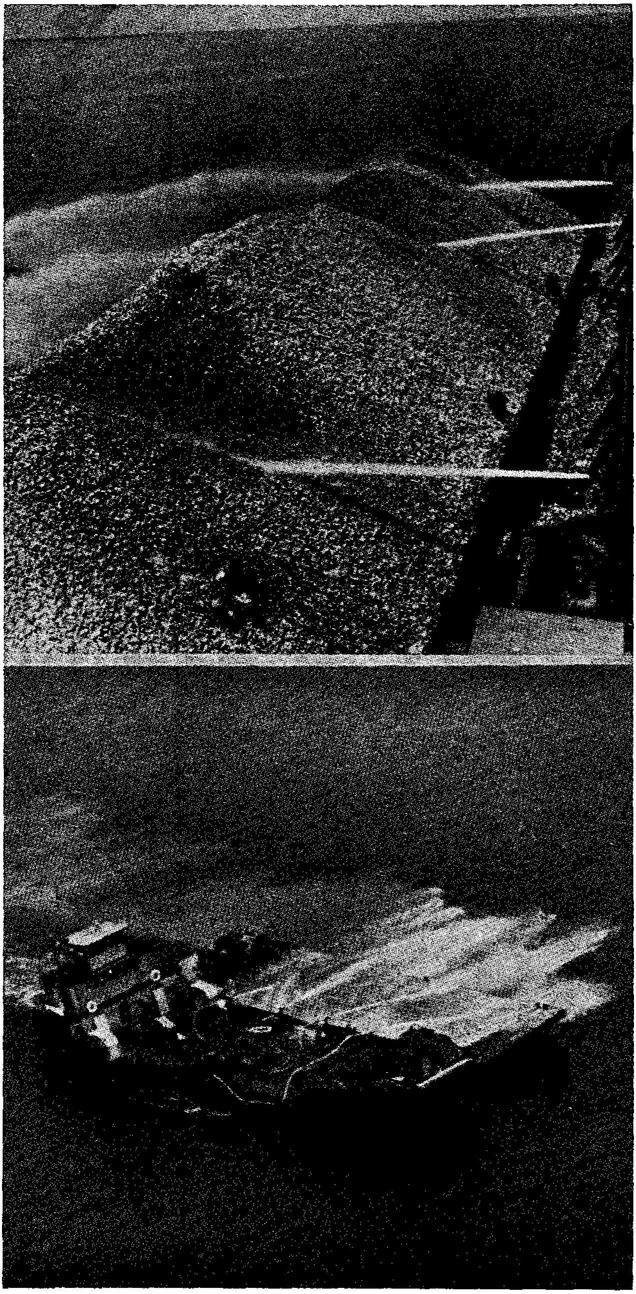


Figure 3.—Barges of mudshell being unloaded for cultch on State of Louisiana seed oyster reefs in 1959.

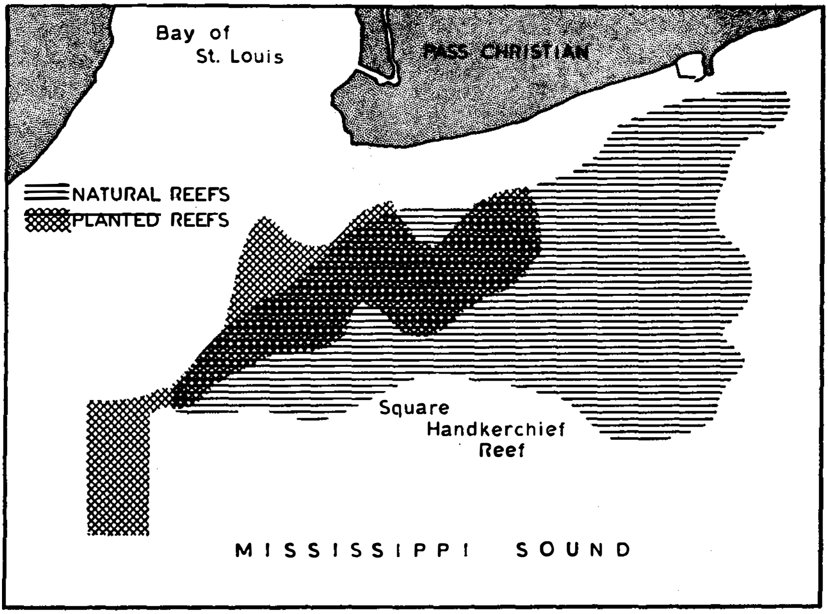


Figure 4.—Reefs planted with mudshell off the Bay of St. Louis, Mississippi, 1968.

These pads became covered with oysters and have made a fine producing oyster bottom over a large area. However, it was killed out by fresh water in late 1968.

Up to about 1930 Redfish Reef extended virtually from Eagle Point to Smith Point across Galveston Bay and in effect, was a low-sill dam across the bay, interspersed with islands of dead shell. In 1926 Dr. Paul S. Galtsoff suggested that this reef be dredged up and hauled away so that better water circulation would take place in Galveston Bay. Galtsoff (1931, p.25) made the following remarks about Redfish Reef: "Redfish Bank forms a natural barrier between the lower and upper parts of Galveston Bay, preventing the free mingling of fresh and sea water. Because of these topographical conditions the upper part of the bay has water of very low salinity. There is a noticeable difference in the growth of oysters between the north and south sides of the reef. No full-grown oysters are found on the north side, though the young ones are abundant and are of good shape. This is due to the fact that oysters are periodically affected by freshets and die before reaching maturity. At present the reef has no commercial value but must be regarded as valuable seed-producing ground." The reef was in effect dug up by the shell dredges and now the water in the area is a great deal deeper, and it has made the finest oyster-producing ground in Texas. More than 100,000,000 cubic yards of dead shell has been moved from this area by the dredges.

The oyster production in Galveston Bay in the fiscal years 1950-51 and 1951-52 was less than 26,000 pounds of meats, while the shell production was estimated to be a little over 14,000,000 cubic yards for the two years. The shell production went on steadily, and the oyster production rose, so that from 1962-63 to 1967-68 it ranged from 1.3 to 4.5 million pounds per year. This oyster production did not increase because of the dredging, but it did increase because of the recent wet years and the creation of proper salinity for oyster growth plus the recent high fertility of Galveston Bay; and the dredging did not interfere with it.

WHAT DO DEAD-SHELL DREDGES DO?

Shell dredges essentially dig holes in the bottoms of the bay, remove the buried dead shell, wash it with water and convey it to barges which are then towed away. The mud and sediment over the buried shell is called the overburden, and the thicker this material is, the greater the cost in getting the shell. The shell dredges move as little mud as possible.

Today, as the shell dredges dig along a cut, they eject all unwanted material back into the hole right behind the dredge as it moves along. This is not an unmixed blessing, however, for during hard cold spells fish like to get in deep holes or channels. In former years unwanted sediment and accompanying bits of shell were ejected to the side where they made a low ridge called a screen pile. These ridges sometimes impeded navigation, but they also caught oysters and formed new reefs. Why the screen pile will catch young oysters and the surface of dead reef shell in lumps or ridges a few feet away remain barren is not known. Today, the screen-pile material is wasted for oyster cultch when it is placed back in the trough of the dredge cut. The bottom would be benefited in general if the mudshell effluent were scattered thinly all around the dredge cut; then, even if the salinity of the water were too low for oysters, bits of algae or other organisms would attach to the shell and the biological productivity of the region would be enhanced. But the shell dredgers have been so sensitized by the vast amount of criticism that has been directed at them for years that they try to fill up the dredge cuts. These dredge cuts fill up quickly just as navigation channels and dug waterways do in the open bays. In a few years the cuts are not to be found.

The dredges do not modify the salinity or temperature of the water to any extent and these factors can be ignored. The only other thing that dredges do to the environment is to raise the bottom sediment and throw it into the water. This sediment is composed in part of nutrient salts, made up of various nitrogen, phosphorus and silica compounds, with some important trace elements and chelating agents plus both dissolved and particulate organic matter amounting to about ten percent of the sediment or bottom muds. This latter material comprises an energy source for the plankton and micro-organisms. Ingle, Ceurvels, and Leinecker (1955) have shown that the total phosphorus in shell dredge "sludge" is 30.0 times as great as in Mobile Bay water; they also found that the nitrate-nitrite component of the sludge is 1.77 times what it is in bay water. Other authors, Anderson (1939), Moore (1930), and Priddy *et al.* (1955), have also treated these matters.

I used to be of the opinion that fertilization of the bays through disturbance of the sediments by channel dredging, mudshell dredging or even the dragging of otter trawl boards over the bottom was important to the fertility and productivity of the bay systems. This may still be true of the Louisiana bays, which are isolated from extensive human habitation by great marshes, and certain bays in Texas with relatively thin human populations surrounding them. But sewage pollution is hyperfertilizing Mobile Bay, the Bay of Biloxi, Galveston Bay, and the Corpus Christi Bay area, and this factor far outweighs the amount of fertilization derived from disturbed bay sediments.

Some 98 percent of the clay and silt from a shell dredge or a channel dredge settles out within 300 yards of the outfall. The fact that most of this material stays is shown by long lines of spoilbanks alongside the navigation channels which remain as permanent adjuncts to the channels. For this reason the dredging contractors for channels or canals are generally required to leave openings in the spoilbanks for small boat traffic, or the spoil is placed alternately from side to side every half mile or so. Some of the papers which have considered the redeposition of sediments disturbed by dredges and the effect of these sediments are the following : Gunter (1957), Gunter, Mackin and Ingle (1964), Hellier and Kornicker (1962), Ingle (1952), Lunz (1938,1952), Mackin (1961) and Odum (1963).

The only other thing a dredge can do is to cover live oysters or to dredge a few of them up. This can sometimes be avoided, but in some cases in good oyster country, small clumps of oysters or even small towhead reefs are everywhere and cannot be avoided. If a screen pile is put down from a shell dredge or a spoilbank is put down by a channel dredge, both will act as a substratum for oysters. For many years the spoilbank of the Corpus Christi ship channel had on it most of the oysters in Corpus Christi Bay.

The dead-shell industry does not leave lasting scars on the bay bottoms, for the whole bay system is filling up rather rapidly and in many places the bottom is soupy mud which spreads and fills in depressions. Shell dredging and channel dredging both throw nutrient elements from the buried sediments back into the water and make them available again. The screen pile from shell dredging made oyster reefs in the past, and where old dead shell reefs have been cut away, as shown by the example of Redfish Reef in Galveston Bay, the water circulation of the bay has been increased, and the oyster production has been enhanced. Additionally the mudshell can be planted to form new reefs. It has been so utilized by the state governments of Mississippi, Louisiana and Florida and has caused new reefs to form where oil operations had been carried on with the use of mudshell spread on the bottom. Mudshell is also being used now in Chesapeake Bay by the State of Maryland for rehabilitation of its reefs (Commercial Fisheries Review, Vol. 31, No. 1, p. 13, 1969). Sediment from mudshell dredging does not carry very far and usually contains bits of shell which act as a substratum for sessile organisms. Oyster beds themselves do not live in a vacuum, and where oysters grow there will also be fish and other organisms.

In summary, the mudshell or dead-shell industry is one of the most harmless activities for the exploitation of a natural resource that there is in this country today. It does not devastate or harm the bay bottoms, and it does not destroy or kill the bay resources. The plowing of a prairie or the cutting down of a forest or the strip mining of coal or the quarrying of limestone rock all leave more lasting scars and often leave barren the areas where they are exploited, while the dead shell industry creates none. In fact by a process of simple management, which has been proved successful many times the mudshell industry can be used to enhance and increase the living resources of any bay in which it operates by the creation of new oyster reefs.

ADVERSE CRITICISMS OF SHELL DREDGING

No oyster biologist that I know takes the stand that dead-shell dredging is harmful to oyster reefs. Some of them, however, and even some who are advising the state governments are not willing to publicize their views because they are not willing to stand up to the ridicule and excoriation which is poured upon them by the sports fisherman, the legal aids who are employed to expound those views, and those who would make political hay of the situation. Anyone who takes the stand that I do may count upon this strong criticism. I have been asked how much the mudshell people are paying me, and somehow it is insinuated that you are crooked if you accept a fee such as lawyers, doctors, architects and engineers do. Then you are an anti-conservationist and other things.

But I am convinced that the antagonism to the exploitation of dead-shell dredging is not in the best interests of the states involved or the nation and that it is designed to destroy a basic wealth-producing resource because of a vast lack of understanding. Thus I think I have an obligation to speak up on this question which was brought to the attention of this organization last year by Eckhardt (1968) in Galveston.

As a beginning let us take up North Carolina and go around the coast. Albemarle Sound, especially next to the Roanoake River, is a very shallow and muddy area and its waters are extremely turbid. I was there in Elizabeth, North Carolina, in 1964 right after a terrible nor'easter had devastated the coast. There were pictures in the newspapers of new channels across the islands and of sand and silt rolled up against the houses close to the peaks of the roofs on the seaside islands and peninsulas. The question under consideration before the North Carolina Natural Resources Commission was whether or not shell dredges should be permitted to operate in Albemarle Sound. One of the victims of this natural catastrophe, who lost everything, as he told us, except the clothes he was wearing, told the Commission with great vigor, "If a shell dredge stirred up the sediment of Albemarle Sound, it would never go down." This was a most curious statement, insofar as the storm had just finished stirring up a million or so times as much sediment as a mudshell dredge could raise. Be that as it may, there are so-called conservationists with comparable views who are only seeking a cause on which to pin wild-haired theories and protests.

Some recent criticisms have developed in Mississippi. They are very much like those found elsewhere. One legislator said that dead-shell dredging in Louisiana had materially reduced the fishing. The fact is that Louisiana is now the leading state in the Union in the production of fishery products. Mississippi has very little mudshell resources, as I said before, and only 4,000,000 cubic yards of mudshell have been produced there since 1951. Louisiana equals that production in a year and Galveston Bay has doubled it in a year, and one time Mobile Bay produced seven times that amount in a year. The Mississippi operation is miniscule and so is its effect.

What actually happened was that three years ago the Chief Inspector and the Marine Biologist of the Marine Conservation Commission placed a shell dredge on an area that was completely free of oysters. Oysters have grown on the screen pile thrown out by the dredge and now the shell dredgers are being accused of digging up the oysters which they caused to exist. The critics of this operation do not give credit for the fact that Mississippi has more than doubled its oyster reef area in the past ten years and more than quadrupled its oyster production and that a large part of this improvement was brought about through the use of dead reef shell.

There is no organized criticism of the mudshell operations in Louisiana, and they are peacefully carried on in the marshes where they are not often seen, along with the largest fishery in the country and, up until the hurricane Betsy, the largest annual oyster production of any state in the nation.

Some of this criticism has broken into the scientific literature. The first paper is by Stroud (1967). It stated that there were 120,000,000 cubic yards of recoverable shell in the Galveston Bay system in 1963 which had been reduced to half that amount by 1967. It is aside from the main point here, but such production is a great deal more annually than Galveston Bay has ever yielded. This shell was stated to be "exposed oyster beds (no more than two feet of overburden.)" We might raise the question as to why a reef with two feet of mud on it is said to be an exposed reef. Three inches of mud will practically wipe out a live oyster reef, and six inches will kill it completely. Furthermore, the bays are sedimenting rapidly, and once an oyster reef is covered with mud it is gone and only becomes more deeply covered with mud. Then the paper goes on to assume that the remaining shell at $2.00 a yard is worth $34,000,000.00 and further, that the perpetually renewable biological resource would be 36 times the differential cost between dead shell and its substitute, which would be limestone. But this argument is based upon the completely false assumption that shell dredging will destroy the marine life of the bay, and it is preposterous. The calculations are an exercise in futility. If the mudshell industry were damaging to marine life it would have destroyed the fisheries and oyster production of Mobile Bay during the 98 years it has operated there, and it would have done the same thing in Galveston Bay where it has been operating for 89 years. Instead, for the past ten years the fishery production and oyster production and mudshell production have been greater in Galveston Bay than ever before.

Eckhardt (1968) gave an urbane political talk, which was published in this journal, in which he started off with the marshes and showed how they had been destroyed, which is no doubt true to a great extent, and lastly he spoke of pollution. He did highlight the fact that the City of Houston let sewage pollution into Galveston Bay. I might call your attention to the fact that this same thing happens in almost every large seaside city following heavy rains. The sewage plants simply cannot take care of the effluent coming into them, and many of them bypass up to half their loads without any treatment whatsoever. Mr. Eckhardt did not bring out the fact that Galveston Bay and many other areas are undergoing what the modern ecologists call eutrophication, which essentially depends upon hyperfertilization by sewage. This is the best explanation of the recent high production of oysters and other seafoods in Galveston Bay, which is higher than at any time in history. Possibly Mr. Eckhardt did not think of making this explanation or felt no necessity for making it because, according to him, the oyster industry has been practically destroyed by the shell dredges, and an explanation of high recent production would not jibe well with his assertions in face of all the data to the contrary. In fact, he presented no data except for figures on the mudshell potential as given by a shell dredger, Mr. Cecil Haden.

Eckhardt bemoaned the fact that cattle can no longer be driven from one side of Galveston Bay to the other from Eagle Point to Smith's Point on "live oyster reefs." This is the reef which Dr. Paul S. Galtsoff recommended be removed in 1926 for the benefit of Galveston Bay. Time has shown amply that his foresight was correct. Redfish Reef was a large, old dead-shell reef with a small number of oysters on the lower flanks. Cattle did cross the bay on this reef, but they would never walk very far on a live, flourishing reef because it would cut their feet to ribbons. The shell dredgers removed most of this reef, as stated above, and today the area is the most productive oyster region in Texas.

Apparently Eckhardt thinks that the old dead-shell reefs, some of which cropped to the surface in Galveston Bay, were loaded and covered with oysters. This is not the case and Hanna's Reef is an example. It is in the stage of an old reef with a few oysters on the flanks and a central hogback of dead shell. The State of Texas would be well advised to cut it up and use the shell and to plant mudshell nearby. By the proper process much larger and more productive reefs could be built than now exist in this region and there would be better circulation of the water between East Bay and Galveston Bay.

Mr. Eckhardt admits that there has actually been an increase in oyster production in recent years, and he indicates that this is because of the increased taking of oysters. No one can quarrel with that argument, but the increased taking of oysters can only come about when there are increased oysters. Actually, there are about the same number of oystermen and a much smaller number of boats in Galveston Bay than in 1935 when the oyster production was much lower. The numbers of fishermen and the numbers of workers in fish houses on shore have declined on the Gulf Coast for many years, even in the face of rising production, due to a better technology and increased efficiency.

The assumption that Galveston Bay is producing less than it ever has and has been terribly damaged by shell dredging simply flies in the face of all the evidence and it is obviously untrue. Thus Eckhardt's whole thesis with respect to dead-shell dredging is false, and his argument with regard to it blows up.

I will say nothing else except that the plan for diverting east Texas river water to the drier area of south Texas will really change Galveston Bay, but the bay will die only when it is filled in with silt. Up to that time it will support life of some sort, but if it becomes so hyperfertilized with sewage that nothing but algal mats will grow in it, then it will be of little use to man.

It is my understanding that the shell dredgers have been put out of Galveston Bay. This means that the state will no longer have the mudshell to be used in the management of Galveston's oyster resources unless it employs its own dredge or contracts for one to supply it with shell.

As an aside, I should like to call attention to the fact that the Vingt-'t'un Islands, an Audubon sanctuary, would be greatly benefited by a mudshell dredge which would throw the cuttings out on the island in the winter when nesting birds are absent. This would repair some of the damage done in recent years by storms.

The last printed report on this matter is by Laycock (1968). It says a great many things, most of them unrelated to the problem, and so many others that I cannot answer them all here. The "mud-spewing dredges" are listed, of course, with pictures designed to make one think they are practically in the Aransas National Wildlife Refuge, and it states that San Antonio Bay will have a bottom of soupy mud when the dredges leave. That is no doubt correct, because that is what the bottom is now and it will continue to be so. There is no reason why the whooping crane should be affected at all by these operations, because if the dredged water would have an effect on them it would have to run uphill. I worked on the available food of the whooping crane years ago (Gunter, 1950). The cranes do not feed in the open part of San Antonio Bay and not very often on its shores.

Without going into the figures myself, I would like for the various upland game biologists who are so concerned about the mud-spewing dredges to calculate how much mud was spewed out by the ship channel dredges through Galveston Bay and the Intracoastal Waterway along the San Antonio Bay margin. They might also calculate how much silt the hurricanes Carla, Beulah, and Candy raised in San Antonio Bay at the conservative figure of one thousand parts per million in the water. In short, the dire misgivings by people who claim to be conservationists with regard to shell dredges are not borne out by any facts and figures that they can bring forth. A great deal of their program for destruction of the shell-dredging industries is based on emotionalism, as a reading of the completely partisan account of Laycock will show. The National Audubon Society, of which I am a Life Member, would be better advised to take another look at the situation in San Antonio Bay.

LITERATURE CITED

Anderson, D. O.
1939. Distribution of organic matter in marine sediments and its availability to further decomposition. Journal of Marine Research, 2: 225-235.

Eckhardt, B.
1968. Death of Galveston Bay. Transactions Thirty-third North American Wildlife and Natural Resources Conferences, pp. 79-90.

Emery, K. O. and L. E. Garrison
1967. Sea levels 7,000 to 20,000 years ago. Science, 157(3789): 684-687.

Galtsoff, P. S.
1931. Survey of oyster bottoms in Texas. Bureau of Fisheries Investigational Report No. 6, pp. 1-30.

Grave, C.
1905. Investigations for the promotion of the oyster industry of North Carolina. Report U. S. Comm. Fish. 29: 247-341.

Gunter, G.
1949. A summary of production statistics and facts related to development of the oyster industry of Louisiana, with a brief comparison with other Gulf states. Publication No. 2, Texas A. & M. Research Foundation, pp. 1-28.

__________.
1950. The generic status of living oysters and the scientific name of the common American species. American Midland Naturalist 43(2): 438-449.

__________.
1951. The West Indian tree oyster on the Louisiana coast, and notes on the growth of three Gulf coast oysters. Science 113(2940): 516-517.

__________.
1952. Historical changes in the Mississippi River and the adjacent marine environment. Publications of the Institute of Marine Science (Univ. Texas) 2(2): 119-139.

__________.
1957. How does siltation affect fish production? National Fisherman, 38(3): 18-19.

__________.
1967. Some relationships of estuaries to the fisheries of the Gulf of Mexico. pp. 621-638 in Estuaries, Publication 83, American Association Advancement Science, Washington.

Gunter, G., J. G. Mackin, and R. M. Ingle
1964. A report to the District Engineer on the effect of disposal of spoil from the inland waterway, Chesapeake and Delaware Canal in upper Chesapeake Bay. U. S. Engineer District, Philadelphia, 51 pp., Appen. A. 23 pp.

Hellier, T. R., and L. S. Kornicker
1962. Effect of hydraulic dredging on sedimentation. Publications of the Institute of Marine Science (Univ. Texas) 8: 212-215.

Ingle, R. M.
1952. Studies on the effect of dredging operations upon fish and shellfish. Tech. Ser. No. 5, Florida Board of Conservation, Tallahassee.

__________.
1964. Shell dredges benefit bays in which they operate. pp. 6-17 in a report to the District Engineer on the effect of disposal of spoil from the inland waterway, Chesapeake and Delaware Canal in upper Chesapeake Bay.

__________, A. R. Cuervels and R. Leinecker
1955. Chemical and biological studies of the muds of Mobile Bay. Rep't. Div. of Seafoods, Alabama Dept. of Conservation, pp. 1-14.

Judson, S.
1968. Erosion of the land, or what's happening to our continents? American Scientist 56(4): 356-374.

Laycock, G.
1968. Deep in the mud of Texas. Audubon 70(6): 98-118.

Lunz, G. R.
1938. Oyster culture with reference to dredging operations. U. S. Engineer Office, Charleston, S. C.

———.
1952. Handbook of oyster survey, Intracoastal Waterway, Cumberland Sound to St. John's River. Spec. Report, U. S. Army Engineers, Jacksonville, Florida.

Lyles, C. H.
1967. Fishery statistics of the United States 1965. pp. 1-756.

Mackin, J. G.
1961. Canal dredging and silting in Louisiana bays. Publications of the Institute of Marine Science (Univ. Texas) 7: 260-314.

Moore, Hilary.
1930. The muds of the Clyde Sea area. 1. Phosphate and nitrogen contents. J. Mar. Biol. Assoc., 16: 595-607.

Odum, H. T.
1963. Productivity measurements in Texas Turtle Grass and the effects of dredging an intracoastal channel. Publications of the Institute of Marine Science (Univ. Texas) 9: 48-58.

Priddy, R. R., R. M. Crisler, C. P. Sebren, J. D. Powell and H. Burford.
1955. Sediments of Mississippi Sound and inshore waters. Bulletin 82, Mississippi State Geological Survey, pp. 1-54.

Rainwater, E. H.
1964. Late Pleistocene and Recent history of Mississippi Sound between Beauvoir and Ship Island. Mississippi Geological, Economic and Topographic Survey, Bulletin 102: 32-61.

Ryan, J. J.
1967. Preliminary report of the sedimentological study of Mobile Bay for Alabama Department of Conservation. Ms., 5 pp. Presented at the 18th Annual Meeting of the Gulf States Marine Fisheries Commission at Montgomery, Alabama, 20 October 1967.

Scholl, D. W., F. C. Craighead and M. Stuiver.
1969. Florida submergence curve revised: its relation to coastal sedimentation rates. Science 163(3867): 562-564.

Stroud, R. H.
1967. Environmental quality. Cost versus benefits. Bull. Ecol. Soc. America 48(2): 47-49.

DISCUSSION

MR. ROLAND CLEMENT (National Audubon Society): We have been somewhat concerned about this dredging for shells on the Texas Coast, and I wonder whether Dr. Gunter would distinguish for us between production and liquidation. The mere fact that we are taking a larger harvest of particular resources does not necessarily mean that we are producing more. Can he assure us that the production has gone up, or is this simply a matter of liquidation?

DR. GUNTER: Getting the shell is, I think, a matter of liquidation, because all of this material will run out. It cannot be reproduced as fast as it is being taken, and the mudshell dredge removes a deposit that is more than two feet thick and that, of course, takes a good many years to grow. On the other hand, there are no signs that our fisheries are being depleted. In fact, I think they have gone up due to hyperfertilization of the bays, but if fertility gets too high, we are going to have a problem with algae there as we have now in some freshwater lakes in this country that were beneficial producers a few years ago.

DR. CLARENCE COTTAM (Texas): I am not a fisheries expert, but I notice in some of your recent statistics that the oyster production in Texas has decreased as of 1968 by well over 25 percent. In recent years, there have been many new oyster areas opened up that never before were exposed to shell dredging. The length of the oyster season has not been increased considerably in Texas. The size of oysters permitted to be taken has been considerably reduced. Also, the size of the areas that have been closed to pollution have had a bearing. However, some of them that were on the border-line before have now been reopened. Further, oysters are much higher in price than they ever were before. Some of the increase is not very encouraging. I think you yourself have pointed out in one of your articles not long ago that a good oyster-producing area, a reef, was worth $600 an acre, and they were getting that much out of it on some of the reefs that you referred to.

It seems to me there is some misconception in some of this somewhere along the line. Would you care to comment?

DR. GUNTER: I would like to point out that the oyster production of Texas is nearly all in Galveston Bay. Oyster production and mudshell production have both declined there in the past year. The reason that the mudshell production declined is that it has been cut out. There is one dredge still operating insofar as I know. At the present time the whole of Galveston Bay and the whole of Mobile Bay are closed because of pollution.

One-third of the area of Mississippi that produces oysters is closed, and that is the creeping paralysis for oyster production. If you take the long-range factor into consideration, much shell dredging and oyster production can be carried on side by side, and you can use the mudshell industry for management of the oyster industry. We do that in Mississippi, and we have done it successfully.

CONGRESSMAN ECKHARDT (Texas): I am Bob Eckhart. With respect to the closing of Galveston Bay, this is merely a temporary matter with respect to flooding. There is certainly no general closing of Galveston Bay, of oyster production because of pollution.

DR. GUNTER: I did not intend to imply that.

POPULATION STUDIES OF SEALS AND SEA LIONS

RICHARD S. PETERSON AND BURNEY J. LE BOEUF
University of California, Santa Cruz

Two years ago we initiated studies of the population dynamics of pinnipeds of the Pacific Coast. Our specific aims have been to estimate the numbers of animals, the rates of change of the populations, the degree of isolation of populations in different regions, and migratory patterns. We have concentrated on the northern elephant seal (*Mirounga angustirostris*) and the California sea lion (*Zalophus californianus*) but have also devoted some attention to the Steller sea lion (*Eumetopias jubata*) and the two fur seals of California (*Arctocephalus townsendi* and *Callorhinus ursinus*).

In this paper, we present data that we have accumulated during the past two years. As studies of northern fur seals on the Pribilof Islands have demonstrated (Kenyon *et al.*, 1954) accurate estimates of population parameters of long-lived pinnipeds require many years of work. Therefore many of our data must be considered preliminary.

METHODS

We have used three primary techniques for studying population dynamics of seals and sea lions: censusing, marking, and behavioral observation.

Censusing of pinnipeds on coastal islands in the Pacific has been done by a number of workers in the past (Bonnot, 1928; Orr and Poulter, 1965). It is a difficult task (Figure 1). The animals are highly gregarious and generally inhabit inaccessible places that cannot easily be viewed, and they take alarm and rush to the sea at the approach of a man. Nevertheless, we have been able to obtain occasional censuses of certain colonies, either by aerial surveys or

Figure 1.—Colony of California sea lions, *Zalophus californianus*, on San Nicolas Island, California. The density of sea lion colonies, and the difficulties of approaching them closely, complicate censusing and observation.

Figure 2.—A group of female and pup northern elephant seals, *Mirounga angustirostris*, at Año Nuevo Island, California. Elephant seals are not readily alarmed by man. Marking and observation are therefore less difficult than in sea lions.

direct viewing. The largest aggregations we are dealing with are no larger than a few thousand animals, and thus censusing is more practical than among the tremendous aggregations of fur seals on the Pribilof Islands, Alaska, for example.

Since there is evidence that only a fraction of the population of any of the species we are studying is ashore at any given time, we have had to develop methods of marking individuals to obtain records of activities and movements. Tagging with small monel tags (cattle ear tags) on the flippers of the animals is useful in some respects, but the rate of tag loss is high, and we have no good method of recovering these small tags since there is no commercial harvest of the animals we study. More useful tags for some work are very durable nylon-plastic tags ("Dalton Roto-tags") which can be read from some distance without handling the animals. During the past two years we have tagged 2600 elephant seals, 1300 California sea lions, and 600 Steller sea lions with monel and plastic tags, in California and Mexico.

For convenience in recognizing animals, we have used different-colored plastic tags for pups on each of the different islands where we have worked: South Farallon, Año Nuevo, San Miguel, San Nicolas (California) and Guadalupe (Baja California).

Some of our most useful results have come from larger markings. We hesitate to brand or otherwise injure animals, since normal behavior is essential to our studies. We find that peroxide bleach marks elephant seals well enough that they can be readily identified from a distance for a year or longer. We can approach sleeping seals for marking without awakening them. These marks greatly increase our ability to locate marked animals quickly. Unfortunately, we have found no comparable way for marking sea lions.

Behavior study is imperative to any population analysis. We have recorded such phenomena as diurnal fluctuations of the numbers of animals on land, seasonal changes in age and sex composition of aggregations, and the reproductive activity of individual males and females through behavioral observation (Le Boeuf and Peterson, 1969).

RESULTS

a) *Mirounga angustirostris*. There are two major centers of population of northern elephant seals: Isla de Guadalupe, off Baja California, and San Miguel Island off Point Conception, north of Los Angeles. Our counts show that approximately 4000 *Mirounga* were born annually at Guadalupe in 1968 and in 1969, and nearly 2000 each year at San Miguel. In addition, there are seven smaller colonies of elephant seals on other islands; the total number of pups produced on all of these together is probably near 1500 annually. By closely studying the annual cycle and behavior of the animals, we have estimated the ratio between adults and newborn young, in addition to direct counting of adults. We find that the total world population of *Mirounga angustirostris* is about 30,000 animals including the 7500 young.

Elephant seals are the largest of the pinnipeds, and until recently have been exploited commercially for their oil. Only a few of the northern species survived extinction on Isla de Guadalupe; and since 1900 the population has grown from fewer than 100 individuals to its present size. Concurrent with this numerical increase has been a steady enlargement of the range of the species. At present the northernmost breeding colony is at Año Nuevo Island, near Santa Cruz, California. Dr. Ian McTaggart Cowan (*pers. comm.*) has evidence that large herds of elephant seals once inhabited British Columbia waters, and thus it is likely that colonies may soon occur farther north. This brings up the subjects of site tenacity and reproductive isolaton of the colonies. We have evidence from tagging that many individuals return to the same colony to breed each year. We have also found a consistent difference in vocalizations of males between some of the colonies. Our tagging studies show, however, that there is considerable interchange in juvenile seals between islands within United States waters, and in addition we have recently found a marked adult male from San Miguel Island on Isla de Guadalupe.

It is difficult to reconcile these indications of isolation, on the one hand, and intermixture, on the other. One factor that may be critical is the social restriction of reproduction to a few individuals. We find that a very few males do virtually all the copulating within a given breeding season (Le Boeuf and Peterson, 1969). Thus, the occurrence of distinctive vocal patterns in one insular colony may reflect the fact that all animals there are individually related, and that intermixture of *breeding* animals between colonies has been minimal. Alternatively, it may mean that the vocal pattern is adopted by young males through imitation of surrounding adults, rather than being fixed during infancy.

b) *Zalophus californianus.* Our studies of California sea lions have led us in different directions from those of elephant seals. There are two large concentrations of *Zalophus* in United States waters, on San Nicolas and San Miguel Islands, of the California Channel Islands. We estimate that approximately 20,000 animals utilized each of these islands during the past two breeding seasons. These estimates are based entirely upon censuses, since behavioral observation of marked animals have not yet been adequate to provide estimates of the numbers of animals at sea at a given time. Very few of the *Zalophus* we tagged during the past two years have been recovered as yet. We have also worked at 13 other locations where significant numbers of *Zalophus* rest or breed. Since many animals at some of these locations come from the large rookery islands, we hesitate to add the censuses of the various areas together. Studies of movements of individuals are needed before accurate population estimates will be possible.

North of the breeding range of *Zalophus,* that is, in northern California and Oregon, large non-breeding aggregations are found seasonally. At Año Nuevo Island, for example, more than 10,000 males come ashore during September and October, although only a few hundred can be found during much of the remainder of the year. Similar fluctuations occur throughout northern California. We have studied these fluctuations at ten locations in northern California, through the cooperation of local residents, and find that the influxes of animals are not always simultaneous nor regular. There is evidence that influxes of sea lions are correlated with periods of abundance of food resources such as anchovy and squid. The theory that fluctuations reflect seasonal migratory habits is not substantiated by the irregularity of our data, but further data may alter this conclusion.

We have also initiated studies of Steller sea lions and of the fur seals of California. These have not yet yielded information on the dynamics of the populations of these animals but they will permit us to obtain such information in future years.

The commercial fishing industry frequently complains of excessive competition from populations of seals and sea lions. We strongly emphasize that adequate studies of the populations, of their migrations and their food habits, are a logical prerequisite to any program of management of pinnipeds.

LITERATURE CITED

Bonnot, P.
1928. The sea lions of California. Calif. Fish and Game 14(1):1-16.

Kenyon, K. W., V. B. Scheffer and D. G. Chapman
1954. A population study of the Alaska fur-seal herd. U.S. Dept. Interior, Fish and Wildl. Serv., Washington, D. C. Spec. Sci. Rept., Wildlife, No. 12. 77 pp.

Le Boeuf, B. J. and R. S. Peterson
1969 Social status and mating activity in elephant seals. Science, 163 (3862): 91-93.

Orr, R. T. and T. C. Poulter
1965. The pinniped population of Año Nuevo Island, California. Proc. Calif. Acad. Sciences, Fourth Series, 32:377-404.

DISCUSSION

MR. ROBERT DELONG (U.S. National Museum): I would like to ask Dr. Peterson one specific question about the distribution of the male *Zalophus*. I believe your statement was to the effect that you would not describe the seasonal movements of these animals as migrations because of their iregularity, as indicated by numerical censuses at various locations in northern California. But is it necessary that the movements of these populations be regular or highly predictable to be termed migrations?

DR. PETERSON: The old theory was that male sea lions regularly left their breeding colonies in central or southern California and migrated northward during autumn. In the spring, they migrated southward again past northern California en route to the breeding grounds. These two seasonal migrations were said to account for seasonal "peaks" in the population in spring and autumn at locations in northern California. An alternative theory is that the populations simply respond to local increases in abundance of certain food organisms such as anchovy and squid. I would expect more regularity in the fluctuations of sea lions than we have found, if indeed there were real seasonal migrations. I see little evidence that there is some kind of regular migration from southern California to feeding grounds off the coast of Oregon, Washington or British Colombia. I tend to think that what happens instead is that the populations move to areas where there is seasonally abundant food.

DR. DAN Q. THOMPSON (New York Cooperative Wildlife Research Unit): I would like to ask the speaker to comment on the new colony of fur seals on San Miguel Island in relation to the oil leakage, and also on how the pinnipeds withstand fouling.

DR. PETERSON: We have no information yet on the relationship between the oil pollution and fur seals. Apparently the San Miguel fur seals remain away from land throughout the winter, as do their Pribilof counterparts. On the second part of the question, we simply do not know what effect oil pollution has on pinnipeds in general. We do know that hundreds of elephant seals and sea lions have become covered with oil, but as yet we have no definite information about petroleum-induced mortality. We feel this is a subject that urgently needs investigation.

DR. JOHN STUBENBORD (Washington, D.C.): Is there any relationship between the sea lions or seals you spoke of and those found in the Galapagos Islands?

DR. PETERSON: I would think there is virtually no interchange between the populations of pinnipeds of the northern and southern hemispheres at the present time. Except in the case of the California sea lion, they represent different species. Most pinnipeds do not live in water much warmer than 23°C, so the warm equatorial water should provide an effective barrier.

MULTIPLE USE OF THE COASTAL ZONE

JAMES T. MCBROOM
Executive Secretary, Interagency Committee on Multiple Use of the Coastal Zone, National Council on Marine Resources and Engineering Development, Washington, D. C.

The Coastal Zone is the interface between land and sea, the land adjacent to the sea, and the sea and sea bed adjacent to the land. The Coastal Zone is also the Great Lakes—part of the marine environment by law—and their shorelines.

The Coastal Zone is a place of unmatched natural productivity and also a place of great attraction for Man and his works.

The Coastal Zone is the locale of estuaries, where fresh and salt water mix and where the resultant mixture is far richer than either sea water or fresh water. Nutrients are carried into estuaries from both the landward side and the seaward side. The result is an amazing productivity of living resources.

The Coastal Zone is a place where more people live than any other place. The 31 states which border on the oceans and the Great Lakes contain 75 percent of our Nation's population. The 413 counties which border on the ocean and the Great Lakes contain 40 percent of our people.

The Coastal Zone is the edge of sovereignty where the rights of the nation give way to freedom of the seas. As the nation's frontier, the Coastal Zone is the locale for a good part of our national defense installations.

The Coastal Zone is where land and sea transportation have their interchange in the ports and harbors whose vitality is essential to the national well being.

The Coastal Zone is an area of special importance for the extraction of oil and other minerals. Most current new oil production is offshore, at the bottom of the near sea.

The Coastal Zone is the place on which much of the commercial and sport fisheries of the nation depend and also the place where a large part of the operation is.

The Coastal Zone is a preferred place to play for millions of our people, including many of those who live far away from it. They go there to enjoy sun bathing and swimming, fishing and boating along the edge of the sea and in the Great Lakes. There they need to be housed, fed, and provided with other services in the booming recreation business.

The Coastal Zone is unique in many respects. One of these is the degree to which the value of privately owned land and other resources is dependent upon the close juxtaposition of non-marketable common resources held in trust for the use of all citizens. The submerged land, the water, the wildlife, and the fisheries resources of the Coastal Zone are not private but publicly owned. These same common resources are the natural attractions for the multitudes of recreation seekers, prospective residents, and many other users of the Coastal Zone. The value of riparian real estate, tourist accommodations, and industrial sites reflects the quality of these common resources associated with them.

The Coastal Zone is unique because of the degree to which activity in one area of the Zone affects uses at great distances from where the action takes place. For example, destruction of part of an estuarine system by a real estate development may damage fish populations used by others many miles away, perhaps even in other states.

The Coastal Zone is unique because of the difficulty in determining boundary lines between private and public ownership of land and water; in many cases, the lines are ill defined or impossible to define.

The Coastal Zone is so important to the nation and has such unique characteristics that it deserves special attention from the Federal and State Governments.

Now that we have discussed the term Coastal Zone, let us talk about "multiple use of." This term means two or more uses of the same area. It means utilization for the benefit of different types of interests. It is a good term—used, and perhaps over-used, by land managers and conservationists about resources of many kinds.

I'll give you a definition of my own of the term "multiple use" as it relates to the Coastal Zone. I think it means planned use of the land and water—management by the public sector; that is, use directed by government at some level. It means a balance between the need to develop and the need to preserve. It means order where there is now disorder.

At the present time, the initiative in changing the face of the Coastal Zone is in the hands of the private sector. These changes are initiated by an industry, a developer, or a promoter. They initiate; they act. The public sector—normally a county government—reacts.

Let it be clear that there is no criticism—intended or implied—of industry, developers, or promoters. It is they who have made our country what it is today.

The thesis advanced here is that the public sector should take the initiative by developing enforceable plans to deal in an orderly fashion with the increasing demand for alteration of the land and water of the Coastal Zone—proposals for Venetian residential developments in estuaries or for new petro-chemical plants there or elsewhere, for example. Let it be clear that I am not suggesting the halting of Coastal Zone industrial and residential development—only replacing helter-skelter with order.

This is not a new or revolutionary concept. The sacred right of private property in this nation has always been subject to some sort of public control over property use. For example, I cannot build a hotdog stand or a service station on my private property in a suburban subdivision. The county zoning plan won't let me.

Counties and other local governments are generally now the only part of the public sector which react to the placement of new industries and new residential developments in the Coastal Zone. While some counties have done a good job in this respect, most of the Coastal Zone counties have a difficult time maintaining that balance between the need for development and the need to preserve. Generally speaking, they are in dire need of new tax revenue and new jobs which the industries and residential developments can provide.

Another level of government—the Federal Government—is too large and centralized to make decisions or prepare plans about the use of private property in the Coastal Zone. Furthermore, the use of federal power for this purpose would be regarded by most as an inappropriate use of that power.

The state governments thus are the level in the federal system which should take responsibility, where they do not now exercise it, for assuring that the public interest is served in the multiple use of the land and water of the Coastal Zone. The state governments are well equipped to provide the balance between the need for development and the need to preserve the vital Coastal Zone of the nation. What I am suggesting is that the state governments prepare and enforce plans for Coastal Zone areas within their jurisdiction to govern the use or non-use of land and water resources.

I also suggest that, because of the national interest in the orderly multiple use of the Coastal Zone, the Federal Government establish a system of incentives and assistance to help the coastal states prepare such plans and to carry them out. However, unlike some other federal assistance programs, the proposal advanced here would not include a "stick" in addition to the "carrot." That is to say, no federal threat to take over this function of the coastal states if they fail to adopt it.

Rather, it is proposed that the Federal Government provide financial incentives and also the services of its skilled personnel to help the states, when requested, and to serve under state supervision.

A great many federal study programs are going forward in the Coastal Zone, and most of them can be helpful to the states in working out Coastal Zone plans. For example, the Federal Water Pollution Control Administration is developing a great deal of information on estuaries and other coastal areas under its study of estuarine pollution. Its report is due in November, 1969.

The Bureau of Sport Fisheries and Wildlife has responsibility for another estuarine study to be carried forward under the authority of what was H.R. 25, and is now P.L. 90-454. The report on that study is due in January, 1970.

The Corps of Engineers is just about to begin a three-year study of erosion problems of the ocean shoreline. The Corps will report to the Congress on this and a variety of related coastal matters.

According to the recent annual report of the Marine Sciences Council, federal agencies are spending almost $30 million in the Coastal Zone in fiscal year 1969.

The Federal Government owns a good deal of land in the Coastal Zone, including that in national wildlife refuges, national parks and monuments, and in defense establishments. The expansion or reduction of these federal land holdings could in future be coordinated with state plans for the Coastal Zone.

The counties and other local governments also can and should be made a part of the process, led by the state governments, of developing and enforcing plans for Coastal Zone areas. Quite clearly, the states will wish to consult and work with the unique knowledge and capabilities of local governments in carrying forward their Coastal Zone programs.

The proposal for the states to assume responsibility for the use by their citizens of coastal land and water has many precedents.

The Commonwealth of Massachusetts, for example, has had the power to restrict the use of coastal lands for more than a century. In 1845, one William Tewksbury was arrested and convicted for removal of sand and gravel from a beach he owned in Chelsea. He appealed. He lost. The Chief Justice said that under state law all property is held under the tacit condition that it shall not be used so as to destroy or greatly impair the public rights and interests of the community.

Since that time, the Commonwealth of Massachusetts has followed that tradition. In 1963 and again in 1965, it enacted laws for the protection of coastal areas. The 1965 Act employs both the police power of the Commonwealth and the power of eminent domain to preserve high-value coastal wetlands.

Also in New England, the State of Maine enacted, in 1967, wetlands control legislation which acknowledges the critical role of local government in Coastal Zone management, but also provides for the expression of a wider public interest. Among other things, the legislation provides that no agency or municipality can fill, dredge, drain sewage into, or otherwise alter wetlands bordering the coastal waters without first receiving approval from *both* the municipal officers in the area *and* the wetlands control board, made up of top state officials.

Moving to the southeast part of the nation, the State of Florida has taken control over the use of its land-water interface—under the Bulkhead Act of 1957, as amended. This Act made possible the establishment of bulkhead lines to separate areas properly suitable for sale by the State from areas not suitable. This Act is administered by the Trustees of the Internal Improvement Fund, which consist of the governor and all members of the cabinet. In May, 1968, an Interagency Advisory Committee on Submerged Land, headed by the state conservation director, was formed. At the same time, a moratorium was adopted on all further sale of submerged land, pending the reports of that Committee. The group concluded that "bulkhead lines should be located at the mean high water line except where the location of lines further offshore can be justified as being in the public interest." It also proposed that where a bulkhead line is relocated and results in reduction of developable land, the State of Florida should consider an appropriate compensation to the owner for the reduction.

The Committee's first report ran into a little difficulty and the moratorium was lifted. However, because of rising public concern and other reasons, the moratorium was reinstated about two months later. Subsequently, the trustees adopted one of the committee reports calling for the policy quoted above for nine coastal counties. Later, the trustees adopted two more reports of the committee, putting the same policy into effect for the rest of the state's coastal area. Another committee report, recommending 26 state coastal sanctuaries, was also adopted by the trustees, and public hearings on that proposal are being held now.

An outstanding example of state action in carrying out public initiatives in the management of the Coastal Zone is the authorization and work of the San Francisco Bay Conservation and Development Commission. This Commission was established by a California state law of 1965, which directed a detailed study of the Bay in order to prepare "a comprehensive and enforceable plan for the conservation of the water of San Francisco Bay and the development of its shoreline." This followed a reduction in the surface area of the Bay by 41 percent, from 680 square miles of marsh, tidelands and water in 1850 to 400 square miles today. The Act was one result of the efforts of an organization called the Save San Francisco Bay Association and other concerned groups. Since it was established in 1965, the Commission has been empowered to issue or deny permits for alterations of the Bay, pending completion of its study.

The final report of the Commission was submitted to the Governor of California just two months ago—on January 6, 1969. The objectives of the program proposed in the report are simple:

1. Protect the Bay as a great natural resource for the benefit of present and future generations.
2. Develop the Bay and its shoreline to the highest potential with a minimum of Bay filling.

The report recommends that a state agency be created or designated by the 1969 California Legislature to implement and enforce the plan outlined in the report. Such an agency would have the power to grant or deny permits for all Bay filling or dredging, in accordance with the standards in the Plan. Also, the agency would control use of the Bay shoreline.

Note both in the Act establishing the Commission and that statement of the Commission's objectives the sought-for balance between preservation on the one hand and development on the other. This is the balance of which I have spoken earlier in this paper.

The commissioners in this organization included public representatives, federal representatives, officials of state agencies, county representatives, city representatives, and state legislators.

Among other things, the report of the Commission includes a series of maps of the Bay on which is indicated the Commission's recommendations as to use or non-use.

There is a strong representation of the conservationist viewpoint in the Bay plans. Over and over again, the maps indicate places which should be perserved for wildlife, for example, as well as recreational areas and public access to shellfish areas. On the other side of the balance, the maps indicate a number of places for future industrial development.

The conclusion in the summary of the report reads:

"The Bay is a single physical mechanism in which actions affecting one part may also affect other parts. The Bay Plan provides a formula for developing the Bay and shoreline to their highest potential, while protecting the Bay as an irreplaceable natural resource. A governmental agency should be created or designated by the 1969 Legislature to carry out the Bay Plan."

This makes a lot of sense to me as a fine example of a planning and management system which each coastal state might well emulate for its entire Coastal Zone.

The proposed program for enhancing state responsibility in the planning and management of the Coastal Zone is consistent with the view of Governor Dan Evans of the State of Washington. Writing in the Seattle *Post-Intelligencer* for December 13, 1968, he said:

> "Their [the States'] position between the Federal government and local governments allows the States to perform a unique function. Because of their size, they are far better able to coordinate activities at the local level, yet at the same time they are large enough to work together and with the Federal government to help manage National goals."

Achieving national goals through federal assistance to states for planning and management of the Coastal Zone is a way to bring order, balance, and true multiple use.

DISCUSSION

MR. TED PANKOWSKI (Izaak Walton League of America): During the course of your remarks, you mentioned on several occasions that the coastal zones are subject to a public trust—areas which the states must hold in trust for the benefit of the public. Do you believe it is consistent with this trust for a state to sell for private development submerged lands which are presumably held in trust?

MR. MCBROOM: Let me clarify what I did and did not say. I said the states should exert more control over their coastal areas than they are doing now, along the line of the San Francisco Bay plan. In the case of Florida, where they own the submerged lands, selling of the lands under a plan developed by the state and publicized to all its citizens I think is all right.

Now, I hope that, if they had a good state coastal zone plan, they would have places where sales should be made and places where sales should not be made. I see no problem in selling land under those circumstances.

DR. RICHARD PETERSON (University of California): Since a good deal of San Francisco Bay involves submerged lands under private control at the present time, is there much likelihood the proposed plan will be adopted?

MR. MCBROOM: I certainly hope so. There was an Act passed in 1965 which set up a Commission to do exactly that. If they are thinking the same way in California now as they were in 1965, then it ought to be passed. Of course, the Commission people tell me that they need all the help they can get.

MR. ROY METZGAR (Maryland State Planning Department): You are talking about Federal participation and assistance. We are getting into tough sledding with wetlands bills in Maryland. One of the key questions that comes up as we look further down the line is that if you assert that it is in the public interest to have state control over the coastal zone, then this becomes a question of equity. If you apply control and say you cannot do this or that, then you are denying a person his rights. You can see that if you are talking about financial assistance it is all in the public interest; but as a private owner sees it, he is losing a great deal.

MR. MCBROOM: That is right. As mentioned in my paper, in Florida, the advisory committee recommended that where a man's development possibilities was taken from him, the State should compensate him for it. On the other hand, there have been a good many court cases in Massachusetts and elsewhere where the court has clearly stated that private property is held subject to the convenience and welfare of the public; and, as I recall, in one case there was no compensation given and the man was just told that he could not change his coastal marsh.

FEDERAL ACTIVITIES IN THE COASTAL ZONE

DAVID A. ADAMS
National Council on Marine Resources and Engineering Development, Executive Office of the President, Washington, D. C.

I frequently characterize the Coastal Zone as the girl next door, who grew up and matured and suddenly became attractive and desirable not only to me, but to all the other boys in the neighborhood. Each saw in her different attributes, each described her in different terms, each had different estimates of her dimensions, but all agreed that she was something pretty special.

So it is with the Coastal Zone. Not many years ago you couldn't use the terms "estuary," "saltmarsh," "eutrophication," or "continental shelf," in general conversation without defining what you meant; today you see them in most any newspaper. It hasn't been too long since there were only a few players in the act, and the script was pretty simple, straight-forward, and with little interaction. Now the play contains enough actors for a major Hollywood extravaganza, and not only are the players coming and going all the time, but their individual personalities and roles are constantly shifting in a manner that is almost impossible to keep up with.

Within the federal establishment, almost every agency is involved in some way in Coastal Zone activities. To list them all would produce a tabulation that would involve many pages and would probably become so confused that even the writer wouldn't understand it. So I'm not even going to try; I'm just going to attempt to describe some of the federal activities that appear to me to be most important from the fish and wildlife manager's point of view, and suggest some that may become increasingly important in the years to come. I might appropriately add at this point that the views I express are my own and are not necessarily endorsed by the agency concerned or by the Marine Sciences Council.

In order to provide some structure for this presentation, I have attempted to group federal programs into the following rough categories:

1. Those related to natural resource evaluation and use;
2. Those related to man-made alterations of the coastal environment;
3. Those related to protecting life and property;
4. Those related to coordinating activities, accommodating diverse uses, and minimizing conflicts; and
5. Those related to national security.

I. NATURAL RESOURCES

The International Convention on the Continental Shelf grants to each coastal nation "sovereign rights" over the continental shelf "for the purpose of exploring it and exploiting its natural resources." The convention further defines the shelf as extending "to the seabed and the subsoil of the submarine areas adjacent to the coast but outside the area of the territorial sea, to a depth of 200 meters or, beyond that limit, to where the depth of the superjacent waters admits of the exploitation of the natural resources of the said areas."

P.L. 89-658 created a 12-mile contiguous fishing zone adjacent to our coastline in which foreign vessels are prohibited from fishing (subject to such traditional fishing rights by foreign states as the United States may recognize). The effect of these two documents is to vest jurisdiction over the seabed resources of the outer continental shelf (between the outer edge of the territorial sea and some imprecise outer boundary) and the marine fisheries (between the outer edge of the territorial sea and the 12-mile limit) in the Federal Government. Living and non-living resources within the territorial limits (with some exceptions, such as migratory birds) are under state jurisdiction.

The Geological Survey is responsible for the investigations to provide the information needed for mineral exploration and exploitation on the outer shelf, and for the management of these resources.

Although the Geological Survey develops the information needed to utilize continental shelf mineral resources, the Bureau of Land Management administers the actual lease program. Since this program began in 1954, it has yielded more than $3 billion in bonuses and royalties to the federal treasury.

Both bureaus of the Fish and Wildlife Service are involved in marine fisheries research and development, but few management or regulatory activities are conducted by either agency (largely because the areas and fisheries most in need of this attention are under state jurisdiction). Among the Bureau of Commercial Fisheries' activities are lobster, shrimp, oyster, salmon, and menhaden resource development programs, seafood processing and marketing programs, advanced technology programs concerned with gear development and utilization, economic research programs, international activities, and federal aid to the states for commercial fisheries research and development and anadromous fisheries. Estuarine and Great Lakes research is conducted in 14 of the Bureau's 20 laboratories; about $5 million of the Bureau's annual budget is oriented toward estuarine work. The near future will probably see BCF placing increased emphasis on analysis of the effects of federal, state, and local laws upon fishing activities; development of aquaculture; perfection of FPC production technology; an improved system of collecting, processing, and disseminating fisheries statistics; more adequate delineation of fish population distributions; and development of more efficient fishing gear.

The Bureau of Sport Fisheries and Wildlife is concerned primarily with marine game fish research and with management of migratory waterfowl through the national wildlife refuge system. Of the 312 units in the refuge system, 78 are in coastal locations, and 52 of these contain significant estuarine areas. The basic goal of the refuge system is to maintain adequate populations of migratory birds and rare and endangered species through manipulation and preservation of land and water resources, for public use and enjoyment.

As recreational demands in the Coastal Zone continue to expand, the programs of the Bureau of Outdoor Recreation and the National Park Service will gain increasing importance. The Bureau of Outdoor Recreation was established in 1962 to serve as a focal point in the Federal Government for activities related to outdoor recreation. The Bureau formulates and maintains a comprehensive nationwide outdoor recreation plan and coordinates land acquisition programs of the National Park Service, the Forest Service, and the Bureau of Sport Fisheries and Wildlife. The Bureau of Outdoor Recreation also administers the Land and Water Conservation Fund, which provides matching grants to the states for the acquisition and development of outdoor recreation areas and facilities. A recent amendment to the Land and Water Conservation Fund Act authorizes the use of outer continental shelf revenues to make up any difference between general annual appropriations and $200 million.

The national park system includes 20 areas with significant marine resources. Eleven are national parks and monuments where resource protection is the major management objective; nine are national seashores and lakeshores where outdoor recreation is the primary objective. Nine marine areas are proposed for addition to the national park system and five are under study. 1969 funding for acquisition and development of coastal-related units was $5.8 million.

II. MAN-MADE ALTERATIONS

As we require a greater intensity of more diverse uses of the Coastal Zone, we find it increasingly necessary to modify natural conditions to suit our needs. In attempting to satisfy these requirements, the U.S. Army Corps of Engineers has perhaps the greatest impact on the Coastal Zone of any federal agency. The Corps is responsible for navigation improvements, channels, and waterways for commerce and navigation, shoreline protection and hurricane protection, and beach erosion control. Corps activities have provided some 500 commercial harbors, 250 small craft harbors, 23,000 miles of intracoastal and inland waters, almost $400 million worth of hurricane protection, and over 100 beach erosion projects. The magnitude of these projects and their effects on the coastal environment provide an opportunity for ecologists and natural resource managers to blend their skills with those of the engineering profession to achieve greater and more beneficial effects than either can obtain alone. All too frequently, we tend to view the activities of the Corps as *prima facie* adverse to our interests and fail to take advantage of the opportunity they may present for enhancing our interests and, conversely, how our knowledge of ecology can be used to achieve engineering objectives.

The last few years have seen a tremendous broadening of the Corps attitude toward coastal engineering. They are now planning a comprehensive, multi-agency, multi-disciplinary study of the effects of construction activities upon coastal ecology; investigating techniques for constructing coastal facilities offshore, where they will conflict less with other shoreline uses; and developing methods for obtaining sand for beach nourishment from offshore sources. In addition, the Corps has employed professional biologists to provide counsel at the district, division, and chief's level.

Two other agencies, the Economic Development Administration and the Department of Housing and Urban Development, can have significant impact on modification of the Coastal Zone. The Economic Development Administration has funded about 200 Coastal Zone projects representing an investment of $178 million. Sixty-four of the projects were technical studies, 20 were business loans, and 116 were for public works such as docks, piers, marinas, cargo handling installations, and other facilities. Programs of the Department of Housing and Urban Development support urban and area planning, urban renewal and redevelopment, open space acquisition, and many other activities within the Coastal Zone.

III. PROTECTING LIFE AND PROPERTY

The formation of the Environmental Science Services Administration in 1965 brought together the functions of the Weather Bureau and the Coast and Geodetic Survey. ESSA collects and analyzes a wide spectrum of meteorological and oceanographic data; provides information concerning present marine weather conditions and predicts future conditions; prepares and disseminates warnings of hurricanes, tsunamis, and other severe weather conditions; and prepares nautical and other charts. Future plans envisioned by ESSA are an accelerated and comprehensive program to determine the circulatory patterns of nearshore waters and a seaward boundary determination program to map the location of the mean low water line. The importance of this last project cannot be overstated. MLW is frequently the boundary between private and public ownership; under the general rule it also forms the baseline from which the territorial sea, the contiguous zone, and other offshore determinations are made; yet, in most cases, its precise location is unknown.

The Coast Guard's search and rescue mission is familiar to all of us. In 1967, the Coast Guard rendered assistance to more than 31,000 vessels, 500 aircraft, and 3,000 individual persons within the Coastal Zone, was involved in more than 2,000 other incidents, and actually saved almost 3,000 lives. Coast Guard Auxiliaries answered an additional 7,000 calls for assistance. As recreational boating continues to increase along our coasts, more and more of the Coast Guard's efforts will be directed in that direction. An expanded network of aids to navigation is required by the recreational boaters; more personnel will be committed to enforcing the Federal Boating Acts, and requests for assistance from inexperienced seamen testing their skills against the ocean will become more numerous.

The Coast Guard's mission has changed to meet the needs of our changing society in other ways. One of the most significant is the degree to which the Coast Guard is involved in coastal pollution control, particularly as it relates to oil pollution. The sinking of the *Torrey Canyon* alerted the world to the hazards incurred in producing and transporting large quantities of petroleum products to meet the demands of our modern economy. In May, 1967, the President directed the Departments of Transportation and the Interior to examine how the resources of the nation could best be mobilized against the pollution of water by spills of oil and other hazardous substances. Their report, *Oil Pollution, A Report to the President,* was released in February, 1968, and contained recommendations for additional legal authority, more effective anti-pollution regulations, stronger international agreements, expanded research and development, and additional funding. Then, in March, 1968, the *Ocean Eagle* broke up off San Juan harbor, further illustrating the need to develop the capability to deal with accidents of this sort. In June, 1968, the President directed the Secretaries of Defense, Interior, and Transportation and the Office of Science and Technology to develop multiagency contingency plans for responding to oil spill emergencies. *The National Multiagency Oil and Hazardous Materials Contingency Plan* was released just last September. It provides a framework for implementing four phases of response (discovery and notification; containment and countermeasures; cleanup, restoration, and disposal;

and recovery of damages and enforcement) including predesignation of Coast Guard On-Scene Commanders for Coastal Zone waters to conduct and supervise field operations and provision of more detailed plans to be developed at the regional and local level. Five federal agencies—Departments of the Interior; Transportation; Defense; Health, Education, and Welfare; and the Office of Emergency Preparedness—are directly involved in implementation of the plan.

The current Santa Barbara incident provided the first field test of the National Contingency Plan. This emergency and the nation's ability to respond are now under close study by the Department of the Interior, the National Interagency Committee established under the Contingency Plan, a panel of scientists convened by the President's Science Advisor, and the Marine Sciences Council. The Congress is also considering a number of bills related to this subject. The precise outcome of all these activities is impossible to predict at this time, but it does appear certain that accidents of this sort will continue to happen, and the nation cannot afford to be caught short when they do.

IV. COORDINATING ACTIVITIES, ACCOMMODATING DIVERSE USES, AND MINIMIZING CONFLICTS

The Marine Resources and Engineering Development Act of 1966 called on the President to develop a comprehensive, long-range coordinated program in marine science, with the assistance of a National Council on Marine Resources and Engineering Development and an advisory Commission on Marine Science, Engineering, and Resources. The Council (chaired by the Vice-President and composed of the Secretaries of State; Navy; the Interior; Commerce; Health, Education, and Welfare; and Transportation; the Chairman of the Atomic Energy Commission; and the Director of the National Science Foundation, with observers from six other agencies) has statutory responsibility to advise and assist the President in policy planning and coordination of the marine science programs of 11 federal agencies. The Commission was asked to examine the nation's stake in the development, utilization, and preservation of our marine environment; to review all current and contemplated marine activities and to assess their adequacy to achieve the national goals set forth in the Act; to formulate a comprehensive, long-term national program for marine affairs designed to meet present and future national needs; and to recommend a plan of governmental organization to support the program and indicate expected costs. The Commission's report, which places heavy emphasis on the Coastal Zone, has just been released, and should be on the "required reading" list of all those interested in coastal natural resources.

Another cabinet-level body, the Water Resources Council, is also involved in Coastal Zone activities. The Water Resources Council (composed of the Secretaries of Agriculture; Army; Health, Education, and Welfare; and Interior, and the chairman of the Federal Power Commission) is responsible for studies and assessments of the adequacy of water supplies in the United States, for maintaining a continuing study of the relation of regional or river basin plans to the requirements of larger regions of the nation, for appraising the adequacy of federal programs, and for making recommendations to the President with respect to federal policies and programs. River Basin Commissions containing coastal areas have been established in the Pacific Northwest, the Great Lakes, and New England. The Council also makes grants to the individual states for planning the use of their water and related land resources. In November, 1967, the Water Resources Council adopted a statement that coastal waters, lake and river shorelines, and islands would be integral parts of the planning activities of the Council, river basin commissions, and other field organizations and state programs authorized under the Water Resources Planning Act of 1965.

Coordination involves much more than policy level operations, however. To be effective it must be exercised all the way down to the individual project level. The Department of the Interior is conducting two studies which should provide a basis for more rational use of coastal resources. The first, authorized by the Clean Water Restoration Act of 1966 and being carried out under the leadership of the Federal Water Pollution Control Administration, concentrates on the effects of pollution upon the various uses of estuarine areas and the effects of population and economic development on water quality. In addition, this study is to recommend a national program for the use of estuaries, delineating the responsibilities of the various levels of government and clarifying private and public interests. A report to the Congress is scheduled for November, 1969. The second Interior study, authorized by P.L. 90-454, is to include an inventory of the nation's estuaries and their natural resources, with particular emphasis on areas which need to be more adequately protected.

The primary federal tool for accommodating diverse interests at the project level is the Corps permit. Under the provisions of The Rivers and Harbor Act of 1899, no structure can be erected in navigable waters without the permission of the Secretary of the Army. Although this authority was originally intended only to consider the effects such activities may have upon navigation, subsequent actions have expanded the breadth of consideration to include fish and wildlife, water pollution, and other non-navigational aspects. The Fish and Wildlife Coordination Act required the Corps to consult with the Fish and Wildlife Service and appropriate state resource agencies "with a view to the conservation of wildlife resources by preventing loss of or damage to such resources." A 1967 agreement between the Secretary of the Army and the Secretary of the Interior essentially guarantees that a permit will not be issued if the Secretary of the Interior advises that the proposed operations will unreasonably impair natural resources or the related environment, or reduce water quality below applicable standards. Whether the Secretary of the Army legally has such discretionary power is now the subject of litigation.

Although the Corps permit has been a useful tool, particularly where states do not have their own mechanism for controlling use of the Coastal Zone, the present litigation sheds some doubt on its applicability to the broad range of considerations necessary in the Coastal Zone. The Congress now has a number of bills under consideration which would drastically change the present permit structure.

V. NATIONAL SECURITY

Approximately one percent of the U.S. shoreline is utilized by the Department of Defense for bases or restricted firing or test ranges. In addition, the Navy sponsors well over one-half of the total federal marine science program. The defense effort has considerable impact upon civilian uses of coastal lands and waters. Lands and waters reserved for defense purposes may be protected from immediate alteration and thus remain open for future options. At the same time, the public may be denied access to and use of these resources, thus removing them from the supply available for recreational and other non-consumptive uses. Although the Navy's marine science program is directed primarily toward defense objectives, it provides considerable support for non-defense activities as well. Bathymetric data provides information for navigational charts; knowledge of underwater acoustics is valuable to the fishing industry; diving technology and physiology are applicable to civilian operations; and about 40 percent of all basic marine research (largely carried out through contracts from the Office of Naval Research to universities and independent laboratories) is supported by the Navy.

In the few minutes available I have attempted to highlight those federal activities in the Coastal Zone which I felt would be of greatest interest to you. I only scratched the surface, but I hope I have conveyed some appreciation of the diversity, magnitude, and complexity of the Federal Government's investment in the Coastal Zone.

DISCUSSION

MR. STUART KAUFMAN (Corps of Engineers): Mr. McBroom earlier discussed a proposal that the Federal Government provide subsidies and planning to help the

States provide viable planning for multiple use of coastal zones. I was wondering whether you would comment on this plan and how, if you agree with this plan, we in the Federal Government should be primarily responsible for the plan and for administrative subsidies.

MR. ADAMS: To understand my own personal viewpoint, you have to consider that for five years I was Commissioner of Fisheries for the State of North Carolina and had jurisdiction over estuarine fisheries. During that five years H.R. 25 came up before the Congress and I vigorously opposed it, not in basic principle but in the area of Federal domination of state jurisdiction. I do agree wholeheartedly that if coastal zone management is to come to pass—and by "management" I mean not only preparation of printed maps but an adequate mechanism for enforcing decisions and controlling land use within the areas—if this system is to come to pass, it must come at the state level. Some states are doing quite well and others are lagging. It could well be that liberal Federal financial incentive would encourage those states on the threshold to go into it.

When you prepare these really pretty maps showing what areas you want to save for public use and it turns out those areas are privately owned, it may cost a few nickels before you can do what you want to do. Also, as an attorney, I am sure you recognize that this is a very difficult question to answer across the board, and in many cases it depends upon the various specific details of the plans and regulations, the titles and the uses that you are concerned with and, in turn, a case-by-case determination by the courts.

Now, the other question was who gets the ball in the federal establishment for such a program—at the present time the Marine Resources Commission report, which recommends a national marine agency, is under rather intensive study by the Federal Government and I imagine by the Congress as well. It would not be quite appropriate for me to comment on that one right now.

MR. HENRY G. RIPPE (New York State Conservation Council): My question about went out the window with your parting remarks. I was going to ask how we get the Federal Government to get the funds to the states. I am speaking specifically about Jamaica Bay. There is a bill in the New York State Assembly to establish a Commission for the preservation of Jamaica Bay. However, in their off-the-record remarks, the politicians doubt the Bill will pass because there is a price-tag of approximately $50,000 attached to it. I was curious as to whether I could induce you to talk to somebody to get the State the money.

MR. ADAMS: Those of us involved in trying to formulate systems of management of coastal zones face the fact as we look around the federal establishment that there are programs all over the place which do part of the job. If you want to acquire land for recreational purposes or for open space, it is simple to have that as a part of your state outdoor recreation plan, and the Bureau of Outdoor Recreation will then from its conservation fund foot a percentage of the bill. On the other hand, if this is associated with urban uses, HUD has open-space acquisition programs.

As you look around, there are all these little nibbles that can be taken but there is no one central coordinated program for the Coastal Zone as such. Many, of course, have felt that there should not be—that the Coastal Zone, if not a piece of continuum then, at worst, is an interface with no characteristics of its own—where land ceases to be land and water ceases to be water.

I am not answering your question very intelligently but I do say that a lot of people are trying to find, first of all, if there is a need for such a program and, secondly, if the need can be demonstrated. No doubt a lot of these questions are going to be answered through the political process, and you are much more a part of that process than I. I merely do a piece of the work here on the staff. I do think this matter will be coming up before the Congress before long and it will be important for the views of groups such as this and individuals such as you to be made known.

MR. FRANK GREGG (New England River Basins Commission Boston, Mass.): The Commissions established under the Water Resources Planning Act are Federal-state agencies that were set up primarily to do the classic kind of river basin planning that we come to recognize throughout the country. I thought that as a point of information you might be interested to know that in looking around the mainland and trying to figure out what the most difficult problem areas were, where federal and state agencies might work together to try to help improve the management of this type of land, we came to the conclusion that the most difficult problems were not primarily river-oriented problems but coastal zone-oriented problems. So, through the mechanism of this committee, federal-state officials agreed that the first planning project that they would like to work on cooperatively through the Commission would be a study of southeastern New England, which includes a number of small streams but also includes Narragansett Bay, Cape Cod Bay and some other estuarine and coastal areas. The fact that this agreement came so quickly and that the priority was recognized suggests that both federal and state officials do recognize very clearly the need for the kind of intensive cooperation and planning for use of the coastal zones. It further suggests that in areas which do have existing federal-state water resource planning mechanisms these can be used to get federal and state officials together to try to reach agreement on action proposals while the Congress and Executive Branch are considering what institutional structure they may want to work out.

POLLUTION IN THE ESTUARINE ZONE

T. A. WASTLER
Federal Water Pollution Control Administration, Washington, D. C.

For the past two years the Federal Water Pollution Control Administration (FWPCA), as part of the National Estuarine Pollution Study, has been taking an intensive look at pollution problems in the Coastal Zone of the United States. I would like to present some considerations about the variety and intensity of pollution problems in the Coastal Zone, particularly as these conditions affect wildlife.

The day has long passed when we could categorize pollution solely in terms of municipal sewage and industrial waste discharges. We must now include as pollution all results of man's activities which adversely affect the environment, directly or indirectly. These include, of course, the sewage and industrial waste discharges as major contributors to pollution; but they also include the damage to habitat and beneficial water use resulting from dredging and filling activities, sedimentation resulting from land erosion related to activities such as agriculture and construction, pesticide use, wastes from watercraft, and spills of oil and other hazardous materials.

While most of these sources of pollution exist in all parts of the Coastal Zone, their magnitude and the intensity of their effects vary with the local environment and stage of development.

Along the northeastern coast of the United States are clustered many large metropolitan areas, densely populated and highly industrialized. Much of the area's relatively abundant rainfall reaches the heavily indented coastline through small to moderate-sized rivers.

The numerous embayments generally have ready, deep access to the open sea and a large range of tide height, all of which indicates that the estuaries along the northeastern coast have generally good flushing rates and should be able to receive and assimilate large amounts of sewage and industrial waste effluents without environmental damage.

Even with these relatively favorable conditions, however, the northeastern coast suffers some severe pollution problems. These are related to the intensive degree of population and industrial development in the Coastal Zone throughout this region, and to the manner in which this development occurred. The major metropolitan areas all date from colonial days and the centers of industrialization had their beginnings in the industrial revolution of the nineteenth century. The sewage systems and industrial waste disposal practices of this region evolved slowly and in an era which gave major emphasis to the exploitation, rather than the conservation, of natural resources.

As a corollary to this historical development, much of the coastal marshland was filled by spoil disposal or for real estate development, thus permanently erasing many acres of wildlife habitat.

In addition, much of the more scenic and accessible coastal area is developed as private residences or as small communities, each with its own small sewage disposal problem.

Not only is the Coastal Zone of the northeastern United States affected by its own pollution sources, but it also receives massive quantities of wastes from cities and industries discharging into small rivers above tidewater. Because of the small drainage basins and rapidly flowing streams, significant quantities of polluting materials reach the Coastal Zone before the natural waste assimilative capacities of these streams can be exerted, thus adding to pollution problems in the estuarine zone.

The pollution problems in this region appear as scattered, but frequent local problems, such as heavy growths of algae in the Boston area, outbreaks of hepatitis around New York, dieoffs of rooted aquatic vegetation on Long Island, and closed or no longer productive shellfish beds all along the New England coast. Some of these are directly related to waste discharges, others to side effects such as overfertilization from waste treatment plant effluents or septic tank overflows, and yet others to dredging and filling activities.

The northeastern coast of the United States is not an altogether bad example in pollution control; all of the states in this region are making great efforts to control and abate pollution and are having considerable success.

It is, however, a very good example of problems which could quite easily arise in other parts of the Coastal Zone if unrestrained population and industrial development and exploitation of the natural resources were allowed to override consideration of the entire estuarine resource.

Other regions of the United States Coastal Zone have their own peculiar problems and problem types; some, as in the populous Northeast, result from people and highly concentrated industry in small areas, and others result from various forms of man's exploitation of the Coastal Zone.

One cannot isolate the Coastal Zone pollution or its effects from the environmental differences existing around the coasts of the United States. For example, a heated cooling-water effluent in Maine might actually have beneficial effects on aquatic life in the vicinity of the outfall, while the same effluent in Florida might prove disastrous to the biota there, primarily because of the differences in natural water temperatures and life forms of the two regions.

There are other differences in the coastal environments which can make their impact on pollution of the estuarine zone.

On the South Atlantic and Gulf coasts there are large areas of marshland and much land drainage which finds its way to the sea through these marshes. The fresh water entering the estuarine zone in these areas contains much natural organic material derived from decayed vegetation; consequently, the capacity of these waters to assimilate additional organic material, such as that in sewage and some industrial wastes, is greatly reduced and higher degrees of waste treatment must be used to avoid damage to the coastal environment.

On the same coasts are many embayments separated from the sea by barrier islands or by peninsulas with narrow inlets into the embayments. Pamlico Sound and Galveston Bay are examples. These embayments are generally shallow, warm, and have weak currents and very long flushing times. Waste discharges into them tend to remain for long periods of time and heated effluents may raise the temperature of an entire embayment, having detrimental effects on some forms of aquatic life. Very high requirements for waste treatment are necessary to prevent damage to the estuarine habitat in such systems.

To use the shallow coastal embayments for navigation requires the dredging and maintenance of extensive channels and consequent disposal of the dredged spoil. Disposal in the embayment itself or along the shoreline frequently results in damage to wildlife habitat or fish nursery areas. Even when the disposal areas are not in the embayment itself, silt and other bottom material resuspended during the dredging process have adverse effects on nearby aquatic life, particularly shellfish.

Coastal areas along the Atlantic, Pacific, and Gulf coasts are, in some locations, underlain with minerals economically recoverable by dredging. Phosphate rock in North Carolina and Florida, and oyster shell in Texas are examples; sand and gravel dredging occurs in nearly all coastal areas. Removal of overburden and its disposal, as well as removal of extensive amounts of the bottom and the dissolving of some of the dredged minerals into the overlying water, can all cause severe water quality and habitat damage.

Deliberate modifications of parts of the estuarine zone for a particular use have sometimes had detrimental effects; some of the side effects of navigation channel maintenance have already been mentioned. More critical, insofar as drastic permanent damage is concerned, is the filling in of large estuarine areas for real estate and industrial development.

In Florida, in particular, many water and marsh areas have been filled in for residential use, each residence having its own boat slip or ready access to communal docks. Sales were made in some locations on the basis of access to recreational waters, yet the numerous finger fills required for development destroyed natural circulation patterns and the aquatic ecology to the extent that many residents must now live with stagnant, smelly boat channels in their back yards.

Fills for industrial development can do the same kinds of damage, but on a larger scale. Water quality, circulation, and ecology can be changed not only by the filling that occurs, but also by the large amount of dredging that is usually done in the estuary to obtain the fill material. A major concern in the area surrounding San Francisco Bay is the extensive damage that has been done to the entire Bay by unrestricted filling of its shallow parts. An intensive study is now underway to seek means for preventing further damage and correcting some of the existing damage. Tampa Bay is another such case. There has been severe modification of parts of the system due to causeway construction and industrial and real estate fills, as well as navigational maintenance.

To these obvious types of pollutional effects can be added the more subtle damages caused by agricultural runoff of pesticides and fertilizers, discharges of toxic chemicals, and discharges of radioactive wastes. In large quantity these types of materials can cause catastrophic damage to the environment, resulting in massive kills of fish and wildlife. In small concentration their effects can be even more deadly, if not quite so obvious. Some of these materials are concentrated in certain organisms to the extent that they may kill other life forms higher in the food chain; or their life processes may be damaged to the extent that they can not produce viable young. The ecological consequences of such pollution can be more far-reaching than the more visible effects of pollution, such as several thousand dead fish floating around an estuary.

Man's impact on the Coastal Zone has been shown to have still another pollutional aspect in recent years. The disastrous consequences of the *Torrey Canyon* oil spill, the effects of other accidental spills since then, and, most recently, the damage caused by the oil well break off the California coast, have dramatically pointed up the environmental consequences that can follow when man loses control of some of his routine business operations.

There are numerous oil wells and sulphur wells in the coastal waters of the Gulf of Mexico, and there are off-shore oil wells in California and Alaska. In all of these areas, and more, there is continuous exploration for additional exploitable reserves of these and other resources. Ships and barges carrying oil and other hazardous cargoes are constantly moving along the Coastal Zone. There is a great potential for environmental pollution in all of these activities, and it will take considerable effort to resolve the potential.

The people of the United States use the estuarine zone in many ways for transportation, for food, for recreation, for living, for mining, and for dumping wastes. Not one of these activities is without blame as a pollution causative in one form or another. Moreover, it is likely that the estuarine zone will continue to be used more and more intensively for these same purposes and probably for others that do not yet exist.

How, then, can we continue to use the Coastal Zone for all these purposes and not destroy it? The complexity and variety of the Coastal Zone and its problems offer many challenges and opportunities not only to scientists and engineers concerned with the technical aspects of estuarine pollution control, but also to local, state and federal governmental agencies responsible for environmental protection.

It is impossible to divorce effective pollution control in an estuarine system from total management of the estuarine resource. The many uses, both land and water, of the coastal environment are so interlocked that using a system for one purpose may affect water quality and ecology to such an extent that it cannot be used for other purposes. Sometimes only a small part of a system may be affected; in other cases the entire estuarine zone may be damaged.

For example, dredged navigation channels are unsuitable for shellfish propagation and for swimming; yet the same estuary can have excellent swimming and shellfish beds away from the navigational areas. At the same time, deepening navigation channels or changing river flow can alter the circulation, water quality, and ecology of an entire system.

A case in point is the harbor of Charleston, South Carolina. Thirty years ago this was a natural deepwater port requiring minimal dredging. When additional fresh water was diverted through the harbor from a power plant development upstream, severe sedimentation problems began to develop. Over a five-year period, the dredging costs went from $160,000 to $3,000,000 annually, and even then a number of docks had to be abandoned because channel depths could not be maintained.

Recent studies have shown that this flow diversion caused the system to become stratified, bringing about drastic changes in circulation, flushing rates, and water quality, plus probably some change in the ecology. These studies also showed that industrial wastes now being diluted and flushed out to sea would remain in the harbor and cause even more severe pollution if the diversion were stopped. This is a very good example of how lack of knowledge, planning, and overall management of an estuary can result in severe economic damage.

Wildlife habitats and fish nursery areas are particularly susceptible to small changes in water quality and circulation. Such habitats develop and maintain themselves because they are exposed to particular sets of recurring environmental changes, upon which the food supplies and reproductive cycles of some life forms depend.

Destruction of wildlife habitats by dredging and filling are direct and obvious, but these habitats are just as surely and as finally destroyed by subtle deterioration of the environment as by dredge and bulldozer.

There is room for cities, industries, people, and wildlife in the Coastal Zone; but to provide unmitigated room for each without damage to the others, the estuarine resource must be carefully managed for the benefit of all. Where uses are incompatible, there must be some portion reserved for one use and some for another; where uses are compatible they must be regulated to the extent necessary to avoid damage to other uses. Knowing that these things should be done is one thing, finding out how to go about doing them is another.

For the past two years, the Federal Water Pollution Control Administration has been making an intensive study of estuarine pollution problems, and Congress has called for a report of the findings by November 3, 1969. A major part of this report is to be recommendations for a national program for the preservation and use of the United States Coastal Zone, including a categorizing of responsibilities at all levels of government.

In making this study FWPCA has consulted all levels of government, as well as many other organizations and private individuals, to obtain a broad base of opinion for the recommended program.

It is our intent that this report will define in depth the values and pollution problems of the Coastal Zone, and that the recommended national program will show that it is possible to have multiple use without multiple destruction.

Remember, however, that no written report has ever cleaned up a stream or an estuary. Pollution is caused by men's actions, and must be stopped by men's actions. It must be stopped by the company that manufactured this paper putting in a waste treatment plant, and by citizens voting *for* bond issues for sewage treatment, and by those who use the estuaries for recreation putting their trash in the garbage bag instead of throwing it out of the boat.

DISCUSSION

MR. P. A. DOUGLAS (Sport Fishing Institute): I would like to ask, in connection with the estuarine water pollution potentials as problems, if in the power industry along the coastal areas there have been developed suitable cooling devices that could utilize brackish and salt water.

MR. WASTLER: First of all let me say that I don't want to indicate that I am an expert on the power industry. However, I am fairly certain that there is equipment that they could use to cool brackish saltwater.

MR. DOUGLAS: I believe the problem from the salt would be in the vapor discharged into the surrounding territory.

MR. WASTLER: They could very well be having such problems. However, if they recirculated and used cooling towers, I doubt if they would have that type of problem.

A SYSTEMS APPROACH TO REFUGE MANAGEMENT

ROBERT H. GILES, JR.
Virginia Polytechnic Institute, Blacksburg, Virginia; and
ROBERT F. SCOTT
Bureau of Sport Fisheries and Wildlife, Washington, D. C.

The objectives of this paper are to direct attention to a new pattern of natural resource management called a systems approach; to describe the significance of current efforts to adopt and implement it in the National Wildlife Refuge System; to review its foundations; to present its advantages and limitations; and to suggest its broader implications and future directions. This approach holds the promise of producing internationally significant rational methods of resource management, of inventing new ways of deciding land use, and of achieving heightened purpose and motivation for professional wildlife managers.

We will describe here the application of a "systems approach," to a prototype natural resource management enterprise of considerable size and complexity. The National Wildlife Refuge System is a federally managed network of lands and waters (over 320 units, about 28 million acres) administered within the U. S. Department of the Interior by the Division of Wildlife Refuges, Bureau of Sport Fisheries and Wildlife.

Throughout the United States, thousands of similar units of land involving millions of acres are managed essentially for benefits from wildlife resources. Some of these units are called "refuges," or select land units managed in a particular way by state or federal agencies to produce public benefits from wildlife resources and their associated environments. Hunting or other uses may or may not be allowed, depending upon management objectives. Although we will here be discussing refuges in the federal system, we are examining them as a typical example of integrated resource management. We believe the concepts presented will be found to have much merit and wide application in the management of all such systems. We also believe a major goal of the National Wildlife Refuge System must be to serve as a paradigm of such management.

It has been said that nothing is so practical as a good theory, and it has been previously suggested (Scott, 1954) that the practice of wildlife management would benefit by a greater and more consistent effort to apply productive theories and techniques developed in other fields. As Watt (1968:4) has put it, "The point is that some fields of resource management are strong in some aspects of theory and technique, and others are strong in other aspects. Each field of resource management has much to learn from the others, and this process of communication can be facilitated by creating a common body of theory and methods applicable to all fields, and contributed to by all fields."

As it happens, the still poorly defined assortment of viewpoints, theories, concepts, principles, and techniques that together contribute to a systems approach were not originally developed in any field of resource management. The systems approach is, rather, a synthesis of ideas and methods that have grown from, and concurrently with, developments following World War II in operations research (Churchman *et al.,* 1957), in systems engineering (Machol, 1965), in game theory (Luce and Raiffia, 1966) and computer systems. The general philosophy and concept is presented by Johnson *et al.* (1967). The compatibility of the approach with ecosystems has been recognized and articulated by Watt (1966) and many others. Watt's recent book (1968) *Ecology and Resource Management: A Quantitive Approach* is a significant introduction to the concepts and applications of systems methodology to natural resource management. Within the scope of a systems approach, an abundant literature exists on simulations of whole systems, on economic and biological optimization, and on decision making under different types of risk.

The special tools of the systems approach are those of modeling, linear and dynamic programing, game theory, critical path methods and program evaluation and review technique (PERT), simulation, decision theory, flow and network diagrams, and construction of systems of sub-systems. Though these tools rely heavily upon mathematics and computer applications, the approach is practical for those not mathematically inclined and not familiar with, or without access to, computers. These tools will serve all levels of the system. Specialists will use these tools, but their rationale will permeate all levels of planning and decision. Their strengths will be sought by those who have problems and see the potentials of the new methods for solving these problems.

A systems approach to refuges and their management, or to anything else, is a style of thought and action that treats animals, organizations, ideas, problems, land, and resources as systems. It is a peculiar perspective or way of looking at the structure and function of refuges. A system is a recognizable "whole" having interacting parts; it is purposive or goal-seeking. The systems approach is an analytical, as well as synthetic approach, that fits ideas to the "input-process-output-feedback" structure shown in Figure 1. Because it is goal-seeking, it forces the recognition that, in wildlife management, output goals are too often poorly defined, if at all.

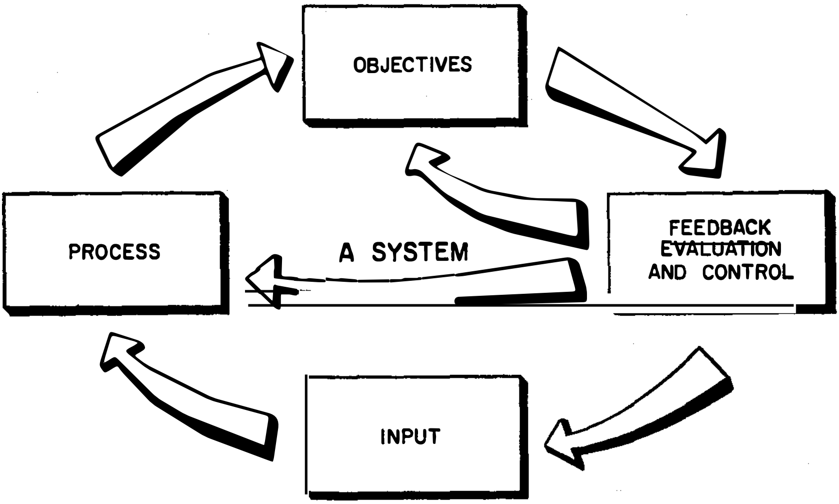


Figure 1.—All systems can be simply described with the components shown here. Arrows represent sequence of events and flow of thought and action.

Because the systems with which we deal are commonly cybernetic in nature, the approach also forces the recognition that evaluative or feedback mechanisms are too often poorly designed, if at all.

The approach is very flexible, for systems can always be thought of as sub-systems. For example, the Refuge System is an organizational sub-system of the Bureau. Organizations, ideas, even refuges can be conceived as building blocks of larger or smaller systems. Many wildlife managers have employed, intuitively, semblances of this approach for years. However, there is growing awareness among industrialists, educators, ecologists, and others that there is much new and special about a systems approach. It is more than just "being systematic" about things. They see that, once embraced, it can pay off in improved management for more benefits than can other approaches. At its most elementary level, the systems approach is an easily-comunicated framework for decision making, and for interpreting natural and social phenomena. It is real, understandable, useful, necessary and, above all, practicable for the effective, integrated management of systems like the national wildlife refuges.

A systems approach is invariably concerned with optimizing. It deals with maximization (e.g., of party hours of hunter recreation of a specific quality) or minimization (e.g., of costs for a desired research output). Thus, the approach resists suboptimization; it is focused on the optimum. The systems approach tends to treat quantitative things quantitatively. It does not reduce all things to numbers, but it does press for clarity and objectivity in expression and understanding.

An initial hurdle that must be overcome is the innate resistance of the uninitiated to a strange terminology which may seem to be merely outrageous jargon. George Orwell is said to have described this kind of problem with gentlemanly terms in this statement: "A mass of Latin words fall upon the facts like soft snow, blurring the outlines and covering all the details." It is not snow, a snow job, that blurs the outlines in modern ecosystem research or natural resources management. It is, rather, the twin problems of conflict and complexity. The first encourages us to seek comprehensive solutions to problems of resource allocation, and the second leads to the peculiarly modern dilemma of the increase in information received seeming to decrease our capacity to understand or act upon it. Long before we have all the information we think we need, we have accumulated more than we can use.

Here is where the systems approach may, through the realities of the computer, concentrate on usable inputs, store tremendous amounts of data and information of all kinds, retrieve this information at fantastic speeds, and report results rapidly for assistance in decision making.

We must, however, clear up one common misconception. Although the computer is a most heroic tool of stystems analysis and must be supported by a system design for its own application, it is only one of the possible tools of a systems approach. The great effectiveness of the systems approach in creating order out of complexity lies in its conceptual organizing and analyzing power with or without the computer.

Chant (1966:209) has advanced similar arguments in connection with programs of integrated control of insect pests. This problem has much in common with the applied ecology aspects of wildlife management. Urging the use of systems theory, he stated that "some will claim that the approach is too sophisticated for an essentially field-oriented applied problem. If the theories of systems analysis and design were adopted by applied ecologists . . . they could be adapted to meet our specific aims . . . once adapted as a routine tool . . . short-cuts and simplifications would undoubtedly follow that would place the tool within the reach and comprehension of us all. I, for one, do not believe that engineers, for example, who use techniques of systems design in their everyday professional activities are, as a group, any smarter than applied ecologists."

Two aspects of the National Wildlife Refuge System have made it a logical candidate for early adoption of a systems approach. First, as a nationwide system of intensively managed units, it is large, and it is exceedingly diverse and complex. Many conflicting interests clamor for a share of its potential benefits. It must, therefore, optimize its production of benefits from the entire system to properly serve the public interest. Second, in the operation of individual refuges, or refuge complexes (which must also be considered in relation to interacting state and private refuge areas), refuge managers do practice applied ecology, and execute refuge operations that are manipulative in nature. They function as "ecosystem engineers" in the highest sense of the phrase and must themselves optimize the outputs of each refuge by allocating scarce resources among competing demands.

In executing this decision-making for optimization, the refuge system administration, and the individual refuge manager must deal with complexity in a spectrum of systems. These include not only the biological organism-environment system, but also the typical economic allocation model, and the perennial organizational and managerial optimization problems. This experience brings home the realization that professional wildlife managers are essentially decision-makers when they are actually practicing the profession of wildlife management. If they are contributing to the practice of wildlife management by conducting research, they are, hopefully, functioning in another professional capacity—that of scientist.

In any event, decision-makers, or scientists, in the face of infinite alternatives or overwhelming complexity, have great need to apply systems concepts. A number of universities have been developing curricula in systems ecology, and the potential for applying these approaches to the practice of resource management has quickly become obvious. Patten (1966:593) believed these developments were "seriously late in coming. The need is urgent if future ecologists are to be able to deal competently with important problems of large-scale environmental pollution and degradation, overpopulation, and multiple-use resource management."

These approaches are now being used in portions of the International Biological Program in this country, and in many other sophisticated research efforts, but we can ill afford to wait for future ecologists. Immediate problems exist for application of systems ecology now. We therefore consider that the current efforts to apply a systems approach to the operational problems of such a typical "real world" entity as the National Wildlife Refuge System will have significance for other resource managers caught up in similar situations.

ADVANTAGES

Some of the advantages of the systems approach as we perceive them within the context of the National Wildlife Refuge System are:

1. It is a logical perspective which can be easily communicated to

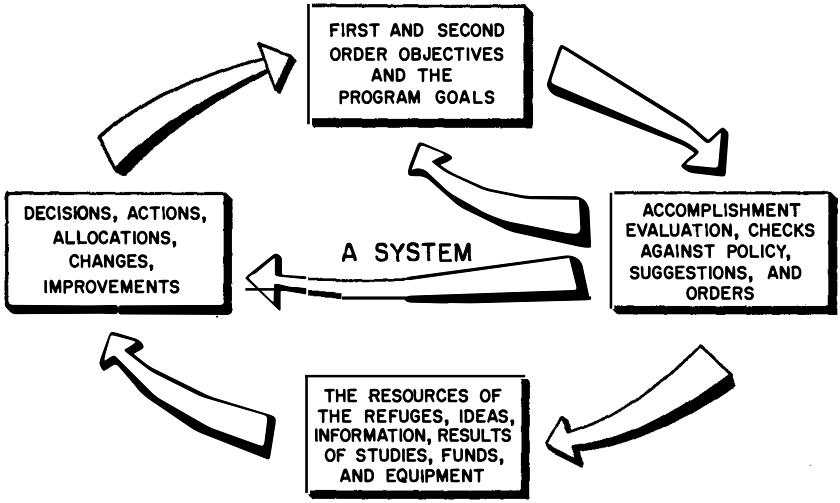


Figure 2.—The components of a general system, shown in Figure 1 are described specifically for the Refuge System.

most members of an organization, as shown in Figures 1 and 2, thereby providing more effective communication and more consistent actions internally. It also becomes a medium for more effective communication externally.

2. It is powerfully focused on increasing efficiency and effectiveness. It is strongly oriented to optimizing the benefits from inputs and processes. Alternatives can be compared and maximum benefits can be predicted, observed, and sought. Cost-effectiveness relations can be studied and used, e.g., user-hunter satisfaction can be rationally increased.

3. It has the capability of dealing with large, whole, interactive, and complex ideas or structures which cannot be adequately handled by any other presently known means. See Figure 3.

4. It is a consuming idea, ravenously using the work of others, avoiding duplication, and, thus, saving time and costs.

5. It has special tools or methods all its own which have powerful capabilities for solving refuge problems.

6. It has powerful methods for maximizing research results. Lead-time can be reduced between data collection and data use.

7. It is completely compatible with and melds smoothly with the digital computer, the most powerful managerial tool available on the modern scene. The rate with which the refuge system can cope with technological progress can be increased.

8. It is a unifying approach that can aid in building morale. Field

staff efficiency and satisfactions can be improved by enabling each person at every level to appreciate more clearly the relationship of his own efforts to the ultimate goals to which these efforts are contributing.

9. It is a dynamic approach that need not be discarded; it is unlikely to "go out of date." Long-range planning can be improved and, thus, encouraged. Past accomplishments and accumulated data can be made to take on more current significance.

10. It is self-corrective, constantly evaluating, updating, and modifying itself based on established criteria.

11. It has strengths for making positive agency responses to increasing resource problems, increasing needs for information, rising costs at all levels, and increasing consequences of wrong decisions.

LIMITATIONS

We must acknowledge that there are limitations to the use of a systems approach in a program such as the Refuge System. However, analysis suggests weaknesses will more often lie with the users than the approach. No tool, no approach to problems and operations as large and complex as those of the Refuge System will be self-sufficient. The systems approach is powerful, but not all-powerful.

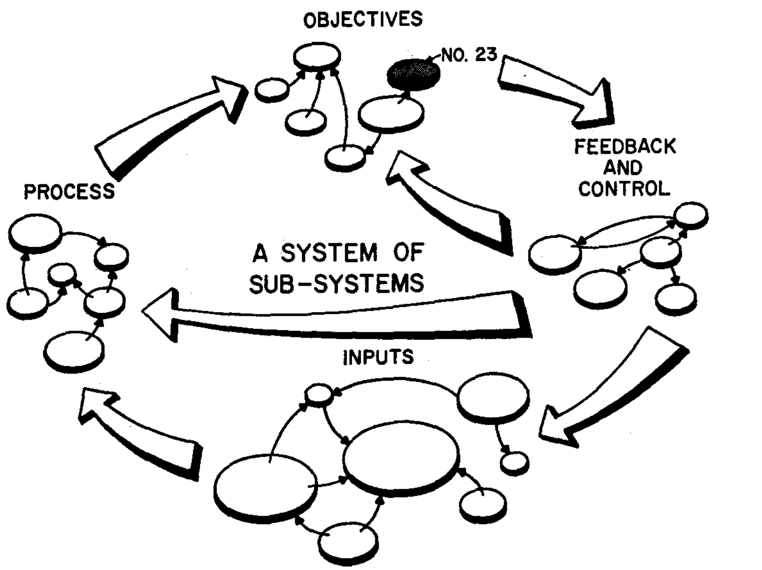


Figure 3.—All systems like the Refuge System can be viewed as a sub-system of a larger system. There are interactions (small arrows) among sub-systems within sub-systems.

One major limitation is that the systems approach is a thoughtful, considered approach, and thought is difficult and time-consuming. Poor systems can be built on poor thought processes and poor information. Fortunately, if the approach is fully operative, healthful feedback will prevent the system from being poor for long.

The time required for implementation is a recognizable limitation, particularly in the initial phases. Inertia must be overcome and momentum generated. Those now impatient with current progress will in the future, with hindsight, see themselves as having been in the "slow" portion of an exponential curve of action and benefits. Wildlife resource management has made a tardy entrance into the systems age, but strides will be great because of the systems tools and resources available. Time will be needed for adopting systems, for allowing personnel to de-bug them, and for learning how to use effectively the answers generated.

Another limitation is that, although wildlife ecologists have accumulated huge quantities of data, they are still short of knowledge on which to build a rigorous predictive theory. They have enough to begin, however. The limitation will eventually be overcome when data tabulation and analysis are seen as machine functions and systems devised so that all can be handled in a short period of time. Analyses can even be run to determine which data contribute the most to good decisions and concentration be focused on these, dropping the unused and nice-to-know.

Wildlife problems have not been well formulated. They are often so vaguely stated that mathematical or objective approaches to their solutions are hopeless. When the need is seen for better formulation of problem statements and more precise statements of objectives (as is demanded by the systems approach) then this limitation will be overcome.

Sub-optimization is a persistent problem and the difficulties of deciding between real and apparent solutions will remain. There are techniques now available for reducing the likelihood of making this error in judgment.

IMPLICATIONS

All of the implications of a systems approach for a major wildlife management agency cannot be predicted. It is a revolutionary and powerful concept, that has already been adopted. Its positive impact and enthusiastic field endorsement has already begun to be felt.

The new systems approach views land and water as specific benefit-producers. Consequently, decisions for acquiring or holding land are based not only on its location, but on the functional character of the land, and the part this function plays in the total scheme of things. The major consequence of the systems approach is a radical shift in emphasis from refuges as physical space to refuges as functional, dynamic, system components.

Similar shifts, largely in concept, but to be manifest in actions on refuges, will include: (1) an emphasis on outputs and benefits instead of an operation and process; (2) quantitative instead of qualitative approaches; (3) team work and pooled resources instead of random individualism; (4) centralization of some major functions rather than a regional or single refuge approach; (5) total wildlife resource management instead of purely a waterfowl emphasis; (6) human benefits from wildlife instead of a wildlife *per se* approach; (7) active land management as well as preservation activities; (8) cost-effectiveness concern rather than a continuance or stand-by consciousness; (9) a thinker-doer image for the refuge manager instead of a "doer-thinker" image; (10) an interactive and catalytic role of refuges as a system, instead of simple additive roles; (11) an offensive instead of a defensive stance against encroachments and constraints; and (12) a standard-setting and leadership role instead of a catch-up or maintenance role.

It can be seen that in the single act of committing itself to systems concepts, the refuge system has set machinery in motion that will result in implementing most of the recommendations described to this Conference by the Secretary's Advisory Board on Wildlife Management just one year ago, at Houston (Leopold, *et al.* 1968).

Even after exhaustive description of the systems approach, a skeptic may still say, "Yes, but what is it?" A visitor from another planet might similarly ask, "What is a scientist? Is it male, female, tall, short, white, or black?" A scientist, of course, is not any particular thing. A scientist is what one *does*. A systems approach similarly is nothing and in fact does nothing until it is used.

Some of "what it does" are as follows: In central and regional offices, it necessitates and provides for effective uses of precise, well-conceived objectives. New objective statements have been developed and are now being prepared for adoption. They are dynamic as feedback continues to clarify and improve them.

It requires that education, policy, publications, records, and accounting be viewed from the question: Will this action help the system achieve *net* (not necessarily gross) benefits from the resources of the refuges and related lands?

It encourages a thought-pattern of optimization. It makes real the self-corrective idea: There is no justification for a systems approach unless there is improved achievement of the objectives of the Wildlife Refuge System. This attitude requires that the benefits produced by the refuges be greater than the sum of benefits from the individual refuges. It requires that they interact synergistically due to skillful management of land, professional, financial, and educational resources.

It encourages more centralized services, but also more emphasis on field stations. It reminds the hierarchy that the man in the field must understand the holistic view if he is to function effectively.

It forces administrative efficiency, discourages duplicative paper work, puts new demands on personnel managers, increases the needs for sophisticated cost accounting, and requires the best quality information, inventory, predictive, and resource-allocation models available.

The Flyway Habitat Management Unit Project (FHMUP) is one example of an early start toward using the systems approach in waterfowl management. In probably no other program is a systematic, deliberate approach to making decisions more necessary. The effects of actions taken at one refuge or by any one of dozens of agencies can be felt up and down a flyway through time. The volume of data involved is overwhelming. A model is necessary to make this complexity understandable.

The Refuge System's inability to see itself in relation to the whole and how it was affecting others is what prompted the project. The Refuge Division set out in 1966 to make explicit and organize the information most needed to determine what it needed to do most in order to assure that the resource would not be in jeopardy as a result of habitat deficiencies on the migration and wintering grounds, to determine where hunting space—another thing it might be able to do something about—was inadequate to meet demand, to determine what the outcomes of pursuing various distribution objectives might be, and to determine what effect actions taken in one area were likely to have elsewhere.

The information developed in this first try is not of the best quality. It needs to be improved. Objectives have not been decided in specific terms in a good many cases. Initially, it will be testing tentative objectives. All alternatives will not become apparent until efforts have been made actually to use the information in an iterative process. Other information, including cost data, is needed. But it is a start toward making the waterfowl manager's life easier, and it is one of the things a systems approach does.

The systems approach also encourages pooling of manpower for efficiency in accomplishing special tasks, the purchase or use of existing governmental capabilities (such as the U. S. Forest Services' Map Information and Display System computer programs), and the use of consultants or other-agency experts.

It encourages improved recruitment, more explicit objectives of behavioral change, measured changes, and feedback for improvements in the conduct of the educational process, both in service and with the public.

The approach encourages refuge managers to think "systems," rigorously define objectives and goals, seek new ways to quantify results, employ "checks" or feedback to improve operations, use sequential and simultaneous methods to solve problems, see the decision process more clearly as a choice between ranked alternatives, and strive for more high-quality, lower-cost inputs to achieve desired goals.

It encourages managers to seek *specific* central and regional office aid in providing systemwide services, such as in ecosystem models, and in providing a broader view within which the consequences of individual decisions can be more clearly appreciated.

It encourages managers to establish clear goals and criteria for evaluating performance. It heightens motivation by encouraging responsible performance toward long-term human benefits. It enables everyone to relate their function to an ultimate goal.

It emphasizes the role of the professional wildlife manager as a decision-maker, making fullest use of his education, and encourages continued education.

It heightens interest in and evaluates manager performance on the basis of rapid utilization of research findings.

It encourages managers to distribute their expertise, plan for methods of building this expertise into sub-systems at all levels, preserve information, and build from, not duplicate the work of others.

CONCLUSION

The National Wildlife Refuge System is a very real, natural resource management enterprise of demanding complexity. As a whole, and in its smallest component activities, it is a useful protoype of the practice of integrated resource systems management. It is now taking steps to become a true operational system as well as one in name. It has launched major changes in definition of objectives and patterns of action. It is developing imaginative programs using the best of managerial science now available. It is beginning to manifest throughout itself what is commonly known as a systems approach. This approach, proven in similar enterprises, offers a compelling, viable alternative to outmoded methods of public land and wildlife management. It is fit for dealing with large, diverse, and complex problems and decisions holistically. It is an approach that seeks and will use effectively inputs from all useful sources. It will feed on resources and technology now available. It will require assistance from the public and professional wildlifers at all levels. It will use better the skills of its competent and improving staff and the abilities of creative new employees. By being late on the natural resource agency scene, the Refuge System can utilize the existing strengths and capabilities of other land management agencies, avoid their mistakes, support their efforts and accomplishments, and plow ground unavailable to these agencies because of their differing missions.

As a true system, the National Wildlife Refuge System will be goal-oriented, highly efficient in the processes of management and supervision of its lands, making maximum timely use of information and knowledge, and exercising dynamic control. Its intent is to achieve a role as the technological, managerial, and conceptual model for wildlife management practices in the United States. In this leadership role, it can provide on its own lands and encourage others to provide significant and continuing wildlife resource benefits for all the people.

LITERATURE CITED

Chant, D. L.
1966. Integrated control systems, *in* NAS-NRC, "Scientific aspects of pest control," pp. 193-218, National Academy of Sciences, Washington, D. C.

Churchman, C. W., R. L. Ackoff, and E. L. Arnoff
1957. Introduction to operations research. John Wiley and Sons, Inc., New York, New York. 645 pp.

Johnson, R. A., F. E. Kast, and J. E. Rosenzweig
1967. The theory and management of systems (2nd ed.) McGraw-Hill Book Co., New York, New York. 513 pp.

Leopold, A. S., C. M. Cottam, I. McT. Cowan, I. N. Gabrielson, and T. L. Kimball
1968. The National Wildlife Refuge System: Report of the Advisory Committee on Wildlife Management, appointed by Interior Secretary, Stewart L. Udall. Trans. North Amer. Wildlife and Natural Resources Conference 33:30-54.

Luce, R. D., and H. Raiffa
1966. Games and decisions: introduction and critical survey. John Wiley and Sons, Inc., New York, New York. 509 pp.

Machol, R. E.
1965. Systems engineering handbook. McGraw-Hill Book Co., New York, New York. v.p.

Patten, B. C.
1966. Systems ecology: a course sequence in mathematical ecology. BioScience 16: 593-598.

Scott, R. F.
1954. Population growth and game management. Trans. North Amer. Wildl. Conf. 19:480-503.

Watt, K. E. F.
1966. Systems analyses in ecology. Academic Press, New York, New York. 276 pp.

———.
1968. Ecology and resource management: A quantitative approach. McGraw-Hill Book Co., New York, New York. 450 pp.

DISCUSSION

MR. RALPH W. DIMMICK (Tennessee): Would you give an example of what you mean by shift of emphasis from wildlife to human values and human benefits?

MR. GILES: I have felt and I think most others have felt, that there has been a conceptual thrust of wildlife management in the past to do things for wildlife. We are sympathetic with this and sensitive to it, and we feel as though it is part of the process, part of the program, part of our intent, but that the consequence of this is that it is unmeasurable. It simply is a reply to do more, to do things for wildlife which can never be completely satisfied.

Now the concept of doing things for people suggests that wildlife is a resource in an economic sense, one that is humanly perceived—that it is a resource from which man receives benefits. Therefore, we will do things for wildlife and with wildlife to receive human benefits. One thing we might do would be to preserve an experience. Another thing we might do would be to manipulate it and very vigorously. Both of these could achieve the objective of heightened benefits from the wildlife resource. This is the emphasis which indicates a subtle but a very real shift to saying and asking the question: "What can I do to help wildlife resources benefit people and how can I achieve greater benefits for the money I will spend?"

MR. CHARLES PURKETT (Missouri Conservation Department): Can you give us an idea of the source of basic information about a potential of a systems program that might be contemplated by an agency?

MR. GILES: Our paper lists some six major sources. They are fairly significant sources, but I would recommend from the beginning two books—*Systems Analysis in Ecology* and *Ecology and Resource Management,* both by Ken Watts. By reading these you can take off in all directions in relation to resource management. There are still others, however.

MR. WALTER E. ROGER (University of Massachusetts): I would like to know that given the fact that this systems approach is validated and that it is probably eventual, there also remains the fact that the systems approach probably needs a central information process center, a central data bank center. I would like to know how you see, in the field of refuge management, who would be responsible for this central process center and be the body pursuing it in the field?

MR. GILES: It would be my opinion that the National Wildlife Refuge System would be the first—and, if not, I will be sadly disappointed—to come anywhere close to that concept. Secondly, I don't really predict that one single central information bank will be built. I think there will be several communities involved in this buildup. Probably some of the larger contractual computer bank type companies will probably be serving in these roles. I hope wildlife refuge systems eventually will be the place where these sort of things would be going on. The complexity of the problem suggests that there is no one place where all of it can be done. Once we get our pipelines opened to where certain areas of competence lie, then this very easily and very nicely comes together because of the concept of the systems approach.

MR. FRANK BARICK (North Carolina): This is an intriguing subject. From the mathematical approach and the systems approach as you have described it, it becomes rather mechanical as well as mathematical and, therefore, appears highly impersonal. Therefore, I wonder to what extent this is going to come into conflict with the human element. Further, once you develop such a system and everything is going in that direction, how do you reconcile it with human interests or local interests and that sort of thing?

MR. GILES: This is a question that always arises as soon as somebody starts talking about computers and systems. However, the thing that intrigues me so much about it is that for one thing I see wildlife management as a decision science. I see the highest use of the human potential for wildlife management in making decisions. I use the analogy of the medical doctor, who rarely gives shots or takes temperatures nowadays. He turns all of these over to a competent individual on his staff. Now, I am not suggesting that all wildlife managers need be of the competence of medical doctors, but I am talking about the professional university graduates in wildlife management who have special competence for handling the wildlife resource.

In essence, what this does is to leave the system involved with most things that are sub-human and, therefore, encourages man toward that which he can truly and actually become.

TECHNICAL SESSION

Monday Afternoon—March 3

Chairman: CHARLES M. LOVELESS
Assistant Director, Denver Wildlife Research Center, Denver, Colorado

Discussion Leader: A. B. COWAN
Associate Professor of Wildlife Management, University of Michigan, Ann Arbor

DISEASE, NUTRITION, AND CONTROL

A SUMMARY OF WOLF STUDIES IN SOUTHCENTRAL ALASKA, 1957-1968

ROBERT A. RAUSCH
Alaska Department of Fish and Game, Fairbanks, Alaska

The purpose of this paper is to review wolf (*Canis lupus*) studies conducted in southcentral Alaska from 1957 through 1968. The study area, which was closed to wolf hunting in 1957, encompasses the Nelchina Basin caribou range, some 17,000 square miles (Skoog, 1968), plus an ill-defined peripheral area in which the "Nelchina wolves" often visit, emigrate to or immigrate from. The total area approximates 20,000 square miles (Figure 1). The study was initiated by the U.S. Bureau of Sport Fisheries and Wildlife in 1957 and was continued by the State following the transfer of game management authority to the new State in 1960.

The federal program was a statewide effort to assess the effectiveness of predator control techniques, to gather biological information on wolves, and to acquire accurate statistics on wolves and their prey (Scott, 1956). The Nelchina Basin study area (Game Management Unit 13 and the north one-half of Unit 14) was planned as a demonstration area where the interrelationships of wolves and their prey could be studied.

The State's program of wolf study has been equally widespread, but the objectives were to provide an understanding of the life history and dynamics of wolf populations under varying degrees of stress and

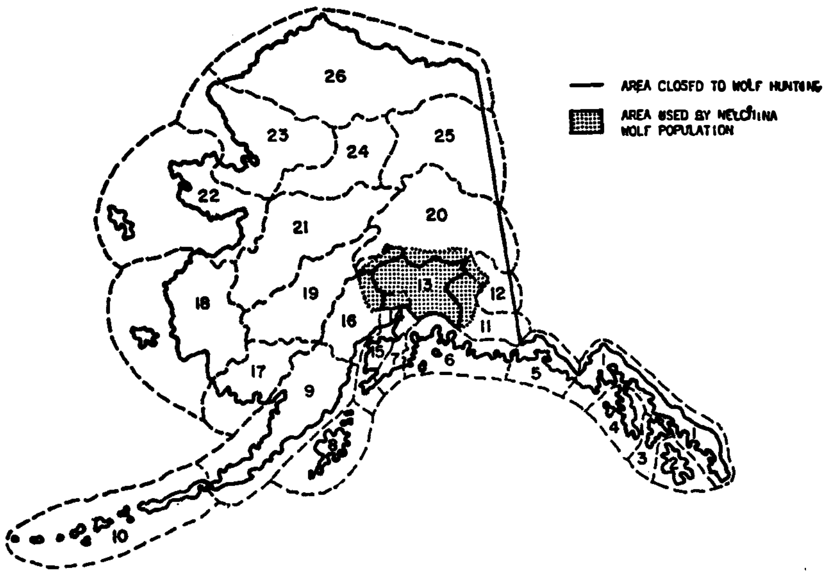


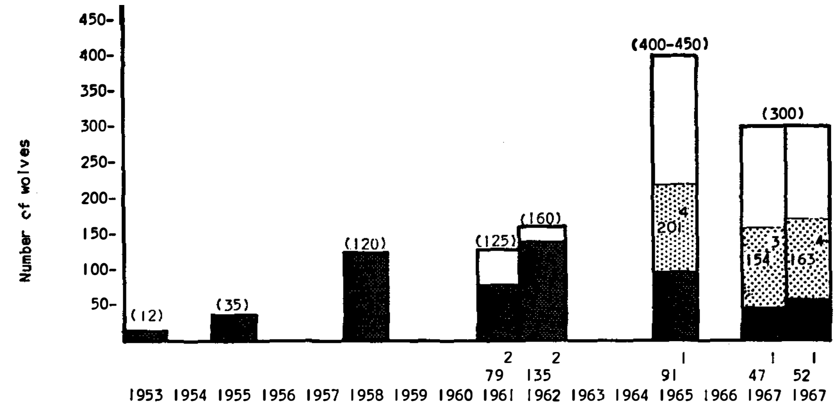
Figure 1.—Alaska game management units and wolf study area.

to continue using the Nelchina study area as a demonstration area (Merriam, 1964; Rausch, 1967). Here, as elsewhere, the primary big-game prey species, moose (*Alces alces*), caribou (*Rangifer tarandus*) and sheep (*Ovis dalli*), were the subject of concurrent studies designed to reveal their abundance, productivity, the magnitude of the harvest by hunters, and their overall well-being. The basic difference between the two phases of the study is that the federal work revolved around evaluating a predator control program whereas the studies of the state were designed to gain an understanding of wolf population dynamics.

This evaluation is comprised of six sections and it is based on data that were collected by biologists and cooperators over the past 15 years. The six sections follow: (1) the wolf population, (2) the moose population, (3) the caribou population, (4) the sheep population, (5) public opinion, (6) discussion and recommendations.

THE WOLF POPULATION

There are no estimates of wolf numbers in the Nelchina Basin prior to 1953, when Burkholder, as quoted by (Atwell, 1962), estimated that there were not more than 12 wolves remaining in the area following intensive predator control and bounty hunting from 1948 through 1953 (Figure 2). Subsequent estimates through 1960 were also based upon his general observations and knowledge of the area.



1. Individual wolves seen during census.
2. Wolves accounted for throughout the year.
3. 105 separate tracks, 9 instances where tracks could not be counted computed at 5 animals per pack, the average pack size in 1967.
4. Individual tracks seen.
( ) Maximum estimate.

Figure 2.—Wolf population estimates, 1953-1967, Unit 13, Alaska.

Starting in 1961 aerial censuses were used to assess the population status of wolves. These surveys were of varying intensity and cannot be considered precise. Wolves, however, tend to follow drainages and other routes that provide easy travel especially in midwinter. Furthermore, the fact that they travel in packs during this period tends to simplify the task of obtaining information on their abundance. Aerial surveys consisted of transects along drainages and contours and capitalized upon the knowledge of the area of various biologists and aircraft vendors. Wolves were tallied by location, color, and pack size. If tracks were seen and the wolves could not be located, landings were made where the wolves fanned out across a lake or in chase, and the tracks were counted. Duplication was minimized by making the counts promptly following snowfall and by plotting the locations of individual packs.

In wolf populations that are increasing, short-term fluctuations caused by high mortality to pups in a given year may significantly reduce their numbers in any one year, as pups may comprise 60 percent of the population. Thus, the observed variation between the 1958 estimate and the 1961 and 1962 censuses may represent real change rather than any inaccuracy in estimates or census techniques (Figure 2). Whatever caused the apparent year-to-year fluctuations is not particularly important to the long-term study. The important fact is that the wolf population did increase rather slowly and reached a peak of abundance in 1965.

In 1967 duplicate surveys suggested a considerable reduction in wolf numbers (Figure 2). The reduction can be related to two or three events: (1) changes in migration patterns of Nelchina caribou; (2) illegal aerial hunting in Game Management Unit 13; (3) relatively poor survival of pups during the summer of 1967.

In 1965 most of the Nelchina caribou left their traditional winter areas and moved into Game Management Units 11 and 12 (Figure 1). Apparently large numbers of wolves accompanied them, and as these Units are open to wolf hunting, many were killed by aerial hunters. The harvest of wolves in these units increased from a total of 54 animals in 1964-65 to 164 in 1965-66.

Portions of the Nelchina caribou population continued this migration pattern in 1966 and 1967, and the harvest of wolves in Units 11 and 12 remained high (108 and 99 respectively) though they did not equal the 1965 harvest. This suggests that wolves were not as abundant, as demand for wolf pelts is good and bounty hunters are interested in hunting close to the supply stations available along the highways that transect this area.

Illegal hunting, particularly in the northwestern portion of Unit 13 commenced on a large scale in 1965 and continued through 1966. The effort in 1965 was considerable, and I estimate that 64 wolves were taken.

If the 1965 estimate of the wolf population was accurate, then the combination of illegal hunting and the kill of wolves following caribou into Units 11 and 12 should not have been sufficient to depress the population severely, as wolves have the potential for increasing by 50 to 60 percent each year if conditions are optimal for pup survival. In fact, pups comprised 60 percent of the wolves killed in Unit 13 and adjoining areas in 1966. As mentioned earlier, high natural mortality in young-of-the-year in heavily exploited populations may contribute importantly to a population reduction similar to that which occurred in the Nelchina wolf population.

Information obtained from the carcasses of 60 wolves killed in Units 11, 12 and 13 in 1967-68 showed that pups comprised 45 percent of the sample, whereas they comprised 60 percent (153 animals) of the sample obtained in 1966 from the same area. The change is more striking if one pack of nine containing eight pups is excluded from the 1967 sample. Obviously pup survival was excellent in this pack, which was larger than average.

Pack size during the winter seems directly related to the abundance of wolves (Rausch, 1967) and the average size of packs in the

Nelchina has declined from 9.7 (22 observations of packs of two or more wolves) in 1965 to 6.2 (39 observations of packs of two or more wolves) in 1967. At present all indices to population abundance (harvests, censuses, age composition and average pack size) suggest the wolf population has declined from the recorded high of 1965. The causes for the decline remain obscure—probably no one factor is responsible for the change in population level. Man's interference, first through illegal aerial hunting followed by a legal aerial hunt in 1968 which removed 120 wolves after the 1967 population estimate had been made, are the obvious factors. The importance of natural population controls should not be overlooked. The combination of kill by humans, plus lowered survival of pups appears to have reduced the Nelchina population at a time when it was approaching a population density of one wolf per 50 square miles. Wolf populations in individual drainages undoubtedly exceeded this average density.

The basis for most problems between wolves and humans revolves around the former's dietary habits. Wolves eat big game that men covet. Because the effects of this utilization of big game has never been adequately quantified, man has assumed the effects are largely undesirable. Slowly, ever so slowly, this broad proposition is being split into manageable questions that should eventually measure each situation in proper perspective. In Alaska we are still attempting to measure what wolves eat during the various seasons when they have a choice of foods, as they do in Unit 13. The primary sources of big game prey in the study area are caribou, moose, and sheep. Caribou are the most abundant followed by moose and sheep (see sections on individual species).

A listing of dead ungulates observed in Unit 13 from 1957 to 1968 reveals 71 moose, 61 caribou, and 1 sheep. Most, but not all, of these animals were killed by wolves. Some undoubtedly had died of malnutrition. In 1962 examination of 45 dead animals suggested only 18 had been utilized by wolves. However, snow depths were tremendous in 1962, and a large number of moose perished. Carcasses of caribou and sheep disappear more rapidly than moose and therefore may be poorly represented in aerial observations of kills. Examination of the contents of 47 wolf stomachs collected during the special hunt in 1968 revealed the following items: moose 24, caribou 5, empty 17, raven and moose 1. Moose are much larger than either caribou or sheep and therefore constitute more meals per animal. This may have influenced the stomach analysis data, but it does not diminish the importance of moose in sustaining these wolf populations.

Wolves do use a variety of foods, including other wolves, even during the winter, but the overall importance of small mammals is not known. I assume that snowshoe hares (*Lepus americanus*) may be important food items, especially during periods of abundance and during the summer months. Studies conducted in Canada (Pimlott, 1967) and on Isle Royale National Park (Shelton, 1966) show that beaver (*Castor canadensis*) are used extensively in some situations. Marmots (*Marmota caligata*) and ground squirrels (*Citellus parryii*), available only during summer months, may also be used (Murie, 1944).

MOOSE POPULATIONS

Records of the abundance of moose in the Nelchina Basin are not available prior to 1952 when the first aerial surveys were flown by the U.S. Fish and Wildlife Service, Office of River Basins. Interviews with long-time residents suggest moose have been abundant in portions of the area for at least 30 to 50 years. Sex and age composition counts from a number of separate areas within the study unit have been gathered every year since 1952. Sample sizes with the exception of 1959 have been adequate to reveal general trends in each year. Pooling information from all moose populations within the study unit may mask local variations that are important to annual management decisions. But for the purposes of a general examination of the status of moose within this area of over 20,000 square miles, I have assumed there is sufficient similarity in two of the basic indices to population condition, calf survival and annual harvest of males, to draw some inferences about possible competition between man and wolves for the use of this resource. Supplementary data such as pregnancy rates and age composition of the moose herd, which are too detailed to present here, support this view for specific areas.

Calf production is portrayed in Figure 3, and the annual harvests are shown in Table 1. There appear to be three peaks and troughs of calf survival to about 6 months that are not of equal amplitude. The extreme high production of 1953-54 cannot be adequately explained. Most of these counts were made on the central portion of Unit 13 where production of calves has been good for years. This may have biased the production figure for 1953-54. Similar population explosions of moose have been observed from time to time on a number of moose ranges in Alaska. Subsequent crashes in calf survival have invariably followed these highs, though the total population almost always remained high at least initially. The lowest estimates of calf survival—1956, 1962, and 1965—all correspond with extremely severe winters, with 1962 being the most dramatic; at least I have the greatest amount of information concerning this die-off of moose. In 1966, 1967, and 1968 the calf crop remained fairly low generally but was good locally in those areas where hunters are killing a significant number of moose.

Moose winter range deteriorated throughout the late 1950's and early 1960's. Many stands of willow (*Salix* spp.) exhibited in excess of 50 percent dead stems. Now, however, slow recovery is evident.

Over the entire period of study wolves may have depressed moose populations locally or held them at static levels, but it is extremely doubtful that they depressed the numbers of moose in the unit as a whole, particularly in view of the fact that two of the lowest periods of calf survival, 1956 and 1962, occurred before wolves were truly abundant. The annual kill by hunters, another measure of the availability of moose, shows little fluctuation in annual harvests since accurate records of harvest commenced in 1963 (Table 1). Hunting pressure since 1963 has not increased rapidly, though in 1968, concurrent with increased exploration for oil throughout Alaska, there was an increase in both resident and nonresident hunting. About

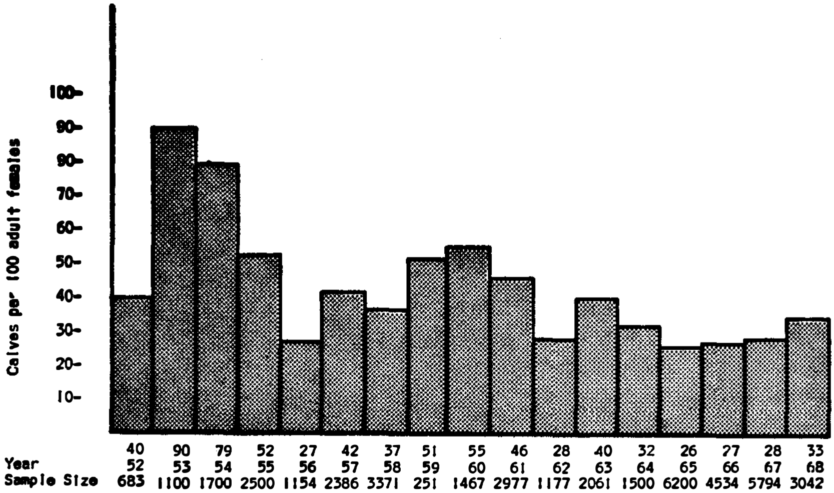


Figure 3.—Moose calf survival to mid-winter, Melchina Basin, Unit 13, 1952-1968.

TABLE 1. HARVEST OF MOOSE, CARIBOU, AND SHEEP, UNIT 13, 1963–1967.

	Moose		Caribou[1]	Sheep
	♂	♀		
1963	1,385	343	3,000	132
1964	1,213	394	8,000	156
1965	1,213	No Season	7,100	143
1966	1,336	181	4,800	154
1967	1,217	314	4,000	152

[1] Caribou harvests prior to 1963 are: 1957, 3,500; 1958, 2,500; 1959, 4,000; 1960, 5,500; 1961, 8,000; 1962, 3,500.

4,000 moose hunters use the Nelchina Basin, and with the existing roads, lakes, rivers, and airfields, 1,200 to 1,400 male moose are about all these people will harvest.

In 1965 I estimated the total moose population within the area to be between 25,000 and 30,000 animals. At present I see no reason to readjust this admittedly rough estimate. Approximately 6,000 moose were counted on selected portions of the area during annual sex and age-composition surveys in 1965 and 1967. In all probability the moose population will continue to fluctuate in abundance, and the best correlation with population adjustments will be with the interactions of moose, winter range, and the extremes of climate rather than with the influences of man or wolves. This prediction could change with the advent of more liberal seasons, or through construction of additional access.

THE CARIBOU POPULATION

Caribou in the Nelchina Basin and associated areas have been subjected to comprehensive studies since the late 1940's. Skoog (1968), who did much of the work starting in the middle 1950's and early 1960's, believes the Nelchina Basin is a core area, one possessing all the attributes of good caribou range. The caribou story has been one of constant increase from the early 50's until 1965 when many of the animals left what traditionally was thought of as "The Nelchina Wintering Areas." By 1962 the population was estimated at about 70,000 plus or minus 18,000 based upon a random stratified census (Siniff and Skoog, 1964).

Harvests have been erratic, ranging from 2,500 upward but never exceeding 8,000 animals even with an August 10 to March 31 season and with a bag limit which has varied from two to four to three animals per hunter (Table 1). The accessibility of animals to the roadside hunters apparently determines the magnitude of the kill. It should be noted that Skoog (1968)and others predicted that seasonal movements of the herd would become erratic as herd size increased. These predictions have been borne out (see Wolf Populations).

In the spring of 1967, an aerial photography census of the calving segment, primarily cows and newborn calves using the traditional calving grounds, supplemented by detailed composition counts during the rut, suggested a fall population of 66,000 animals (Hemming and Glenn, 1968). This estimate, however, did not include the animals in several peripheral areas. Clearly a substantial population remains on the traditional areas at least part of the year, and the populations in the surrounding areas have increased substantially either by egress from the Nelchina herd or from natural increase, probably for both reasons.

The annual kill by humans mentioned earlier is greatly influenced by the proximity of the herd to the highway system. Increased harvests depend upon an increased number of hunters or better access. Competition between man and wolves for caribou has not occurred at this time. Calf crops are good and caribou abundant.

THE SHEEP POPULATIONS

Studies of Dall sheep in this area have been limited to an accurate assessment of harvest (since 1963) and periodic aerial surveys (since 1949). Sport hunting for three-quarter curl or larger rams may have altered the sex composition of the population, but probably has not influenced total numbers. Wolves seem to have had little impact on total abundance of sheep. In the Talkeetna Mountains, part of Unit 13 and adjoining 14, Scott (1951) estimated a population of 626 sheep. In 1967 Nichols and Erickson counted 1,295 sheep on this range (Nichols and Erickson, 1968). The Watana Mountain sheep population, near the center of the best wolf range in Unit 13 and isolated from other sheep range, persisted throughout this study, and 222 were counted in 1967. The harvest of three-quarter curl rams in Unit 13 has been remarkably stable since 1963, the only period for which accurate records are available (Table 1).

While wolves undoubtedly use sheep, food habits studies mentioned earlier suggest sheep were not important components of the winter diet of these wolf populations. Unusual winter conditions may cause sheep to be more available to wolves (Murie, 1944). The extent that wolves eat sheep during the summer has not been determined. This is one of the objectives of current studies. Wolves denning in or utilizing alpine areas eat sheep during the summer months, but the significance of this use to the welfare of a trophy species is conjectural.

PUBLIC OPINION

Measuring change in public opinion over a period of time is indeed frustrating. Often individuals who have changed most insist that they have not altered their opinions at all. If, however, written and oral statements are useful in measuring these changes, then the Alaskan attitude toward wolf management has undergone dramatic change in the past 15 years.

The history of wolf management through the use of bounties, poison, and aerial shooting is documented in several publications (Lensink, 1959; Rausch, 1961 and 1964). Official programs for wolf destruction had widespread public support from 1915 through the early 1950's. In the late 1940's and early 1950's an expanded program under the U.S. Fish and Wildlife Service encountered some public opposition because poisons—strychnine and cyanide—were not selective. Often bears (*Ursus arctos* and *U. americanus*), fox (*Vulpes fulva*), wolverine (*Gulo gulo*), and ravens (*Corvus corax*), were killed. Public criticism of the predator program and recognition by professional biologists that caribou, moose, and sheep were sufficiently abundant to provide for both subsistence and recreational hunting seem to have been responsible for convincing the public that it would be "safe" to close Unit 13 and part of Unit 14 to wolf hunting. Nevertheless, the idea was criticized, and at least one sports club conducted an independent investigation into the entire predator control problem. They concluded that predator control in some form was desirable.

During the period 1957 through 1963 wolf populations in Unit 13 increased several fold but their relative scarcity and the obvious abundance of big game seem to have had a tranquilizing effect on the public. As the wolves became more abundant and were frequently seen by local residents and as guides started having difficulty in obtaining trophy moose in some parts of Unit 13 following the 1962 die-off, there was a considerable outcry for opening the area to wolf hunting and trapping. In 1965 a limited trapping and hunting season was authorized by the Board of Fish and Game (the Department's regulatory body).

Political pressures continued to mount, culminating in an aerial-hunting season in 1967-68. A dispute arose between the Board and the Department over implementation of the hunt. Eventually the Board ruled that the hunt would be for 300 wolves, and the hunt proceeded.

The pressures were not entirely one-sided, however, as those citizens favoring rational management of the wolf population mounted an attack against aerial hunting, poison, bounties, and formal predator control in general. In 1968 the State legislature enacted a law requiring written consent from the Board of Fish and Game before any state agency could use poison; enacted a law giving the Board sole authority for establishing or abolishing bounties on wolves, wolverine, and coyotes; and considered, but did not pass, a bill that would have made it illegal for anyone to shoot animals from an airplane. At no time during the dispute did anyone advocate returning to a formal predator control policy in southcenteral, interior, or arctic Alaska.

DISCUSSION AND RECOMMENDATIONS

In Unit 13 during the period of 1953 to 1967 human utilization of the wildlife resource undoubtedly increased. In fact, it is probably the most important recreation area in Alaska. Access to the area through road construction and improvement and technical advances in design and construction of airplanes, tracked vehicles, and other off-the-road vehicles have contributed to this increased exploitation. Recently, the sales of hunting licenses and the distribution of moose harvest and sheep harvest tickets suggest that proportionately fewer residents are buying hunting licenses. However, total sales continue to increase because immigration rates are high.

Management of this complex of carnivores and ungulates must recognize changes in human attitudes as well as changes in the numbers of animals and their habitat. The Nelchina wolf population probably will be most beneficial to all interests if it is managed at a level where some sport hunting and trapping can be allowed each year. I suggest that to attain this goal there should be from 200 to 300 wolves in the fall population. Downward population adjustments of wolves might be advisable following exceptionally severe winters or other major catastrophies to ungulates, such as disease. For example, brucellosis is prevalent in the Nelchina caribou herd but at a low level. Under optimal conditions of stress or other unknown factors it could become a major decimating factor resulting in a much reduced survival of calves. Then serious thought might be given to reducing utilization by wolves and humans; however, there is no assurance that intense exploitation of the caribou might not be the "best cure."

Methods for utilizing the surplus wolves should include sport hunting and trapping. If surpluses exist by midwinter, I recommend regulated recreational aerial hunting even though it is controversial. The Nelchina Basin has so many lakes, ridges, rivers, and other terrain features where aircraft can land to retrieve wolf carcasses that general aerial hunting without adequate controls can only lead to severe management problems resulting from overutilization of the wolf resource. This may have occurred in 1968.

A great deal of worthwhile information concerning the rate at which a protected wolf population may increase and its effect upon lightly hunted moose, caribou, and sheep was obtained. I conclude that at the level of exploitation experienced during the study, there was no significant conflict between humans and wolves for utilization of the ungulate resource. However, direct competition is inevitable as human utilization of the ungulate resource approaches annual net production.

In the future wolves may be extirpated from large areas of suitable habitat either intentionally or inadvertently. In fact, this happened in Units 7 and 15 (Figure 1) about the turn of the century and in large portions of Units 13, 14, and 16 in the late 1940's and early 1950's. The study conducted in and adjacent to Unit 13 provided future game managers with some insight into the potential of wolves to repopulate suitable habitat even in the face of continued exploitation.

Wolves were generally distributed throughout Unit 13 by 1960-1962, shortly thereafter bounty hunters commenced killing a few in portions of Units 14 and 16 where wolves had been absent or extremely rare for several years. By the mid-1960's wolves were seen in the Matanuska Valley, Alaska's most intensively developed agricultural area, and a pack was sighted within a few miles of Anchorage. Finally, in 1968 a pack of 10 wolves was seen on the Kenai National Moose Range, Unit 15, by Department personnel. Wolves had been absent from this area for 60 to 65 years.

I cannot prove that the reestablishment of wolves in areas adjacent to Unit 13 resulted from egress of Unit 13 wolves, but the circumstantial evidence is compelling.

Public attitudes toward wolves in Alaska have changed during the past 15 years, and the Nelchina study may have been extremely important in this education effort. Most of the public clearly wants a rational management of all game including carnivores. Furthermore, direct control of carnivores by the Department will probably be limited to trapping, aerial shooting or chemo-sterilants if the latter become practicable. The use of poisons, strychnine, 1080, or cyanide, none of which is truly selective, in southcentral, interior, and arctic Alaska, cannot be justified, nor will the public accept such antiquated management tools.

The study resulted in one major disappointment which stemmed from the Department's inability to defend the study when the wolves reached a peak of abundance in 1965. This failure, which included inability to enforce regulations, failure to communicate effectively with the public, and an open disagreement with the Board of Fish and Game, was, in my opinion, due to the fact that very little effort had been made to educate the public about the goals of the long term study. Perhaps this phase of the study was doomed to failure from the beginning, as the site selected was already recognized as one of Alaska's prime big game ranges, and human reaction to competition from wolves, real or imagined, could have been predicted.

Future studies designed to measure the interrelationships of wolves, mixed stocks of big game, and recreational hunting should procede only after a thorough public information program reveals broad support for such an endeavor. Furthermore, such sites should not encompass areas where human utilization of the ungulate resource is approaching the sustained yield. Few such areas remain in Alaska—Mt. McKinley Park and Katmai National Monument are unsuitable because man as a hunter is excluded and the arctic wildlife range does not have a good cross section of ungulate prey. Perhaps only the Tanana Hills in Unit 20 has the desired species and other characteristics necessary for a similar research project.

SUMMARY

Wolves were protected from 1957 to 1968 in an area of southcentral Alaska encompassing approximately 17,000 square miles. Wolf numbers increased from 12 in 1953 to 400 to 450 by 1965. At this point illegal aerial hunting, legal hunting of wolves that followed the Nelchina caribou into Units 11 and 12, and relatively poor survival of pups during the summer of 1967 resulted in lowered wolf populations by late 1967. A further reduction took place in early 1968 when Unit 13 was reopened to aerial-hunting.

Studies of ungulate prey, moose, caribou, and sheep, show that their utilization by wolves did not interfere significantly with human recreational use of the same resource. Competition between the two predators could create problems if human utilization approaches the net annual increase of ungulates.

ACKNOWLEDGMENTS

I gratefully acknowledge the contributions of a large number of individuals who initiated or conducted phases of the study. Unfortunately, not all of them can be named here. The study was initiated through the efforts of Robert F. Scott, John Buckley, Maurice Kelly, Urban Nelson, and Clarence Rhode (Deceased); Bob Burkholder was the principal investigator through 1960; Gerry Atwell, Richard Winters, Ronald Skoog, Richard Bishop, and Arthur Bratlie (deceased) conducted field investigations and surveys of wolves from 1961 through 1967. Robert Weeden criticized and improved the manuscript.

The study was funded, in part, by Federal Aid to Wildlife Restoration Project W-17-R, Alaska Department of Fish and Game and U.S. Bureau of Sport Fisheries and Wildlife cooperating.

LITERATURE CITED

Atwell, G.
1963. An aerial census of wolves in Nelchina wolf area. Proc. Alaska Sci. Conf. 14:19-83.

Hemming, J. and L. Glenn
1968. Caribou studies, Alaska. Unpubl. Segment Report W-15-R-2 and 3, Work Plan L:1-41.

Lensink, C. J.
1959. Predator control with the bounty system in Alaska. Alaska Dept. Fish and Game, Juneau. p. 10 (Mimeo).

Merriam, H.
1964. The wolves of Coronation Island. Proc. Alaska Sci. Conf. 15:27-32.

Murie, A.
1944. The wolves of Mt. McKinley. U.S. Natl. Park Svc., Fauna Ser. 5, Washington, D. C. 238 p.

Nichols, L and J. Erickson
1968. Sheep studies, Alaska. Unpubl. Segment Report W-15-R-2 and 3, Work Plan N:1-51.
Pimlott, D. H.
1967. Wolf predation and ungulate populations. Am. Zool. 7(2):267-278.
Rausch, R. A.
1961. Present status and possible future management of wolf populations in Interior and Arctic Alaska. Proc. Alaska Sci. Conf. 12:28.
————————.
1964. Progress in the management of the Alaskan wolf population. Proc. Alaska Sci. Conf. 15:43.
————————.
1967. Some aspects of the population ecology of wolves, Alaska. Am. Zool. 7(2): 253-265.
Scott, R. F.
1951. Mountain sheep studies. Unpubl. Fed. Aid Study, W-3-4-6-R-6, Work Plan F. Alaska 6(1):64-95.
————————.
1956. Wolf management studies. Unpubl. memo to Supervisor, Game Restoration, Alaska. 11 pp.
Shelton, P. C.
1966. Ecological studies of beavers, wolves, and moose in Isle Royale National Park, Michigan. Unpubl. PhdD. thesis, Purdue University. p. 308.
Siniff, D. B. and R. O. Skoog
1964. Aerial censusing of caribou using stratified random sampling. J. Wildl. Mgmt. 28:391-401.
Skoog, R. O.
1968. Ecology of caribou in Alaska. Unpubl. Ph.D. U. of Calif., Berkeley. 699 p.

DISCUSSION

FRANK BARICK (North Carolina): We are very much concerned in North Carolina about the impact of dogs, stray dogs primarily, on deer. Did your study include an evaluation of the amount of food ingested by wolves in relation to body weight and, if so, whether this might serve as some basis for reading values into potential impact of stray dogs throughout the Southern Appalachians or wherever they might be?

MR. RAUSCH: This particular phase of the study did not attempt to evaluate the amount of food necessary to sustain a wolf. We have, however, looked at 1,000 or 1,500 killed, from aircraft, and made some measurements on the amount of moose or caribou or sheep in the digestive system.

It might be best if we got together and discussed the data. It doesn't differ too much from what Dave Mech published.

MR. LA SALLE (Minnesota): How did you count your wolves?

MR. RAUSCH: Our census in later years consisted of flying over drainages, on contours, over most of the area, using a 150 Super-Cub following fresh snowfall, and locating the packs. In places where we could not locate the packs, we landed when they fanned out from the chase or fanned out on the lakes.

MR. LA SALLE: There is an interest in our Minnesota Legislature at the present time to give the timber wolf in Minnesota more protection. There has been no bounty on the wolf for four years. One bill has been introduced to make the timber wolf a State animal. We are hopeful the timber wolf in Minnesota will gain some form of legal protection.

FROM THE FLOOR (New York): You indicated that wolves were found to prefer moose over caribou. Are moose easier to catch than caribou?

MR. RAUSCH: I wish I could answer that. There are about 25 to 30 thousand moose in my opinion in the area and perhaps upward of 70,000 caribou. Yet we find the wolves take more moose than caribou. I really don't know whether moose are easier to catch.

MR. R. W. STUART (North Dakota): Is there much of a seasonal preference for moose?

MR. RAUSCH: Yes. I should have pointed out that the data we have are primarily from the November through April, and my comments relating to what they seem to prefer and to what they are eating should be confined to that period of time. I frankly don't know what they are eating in summer; and it could be small mammals. Possibly even sheep, during some other months, may be significant.

DR. A. B. COWAN: You have suggested failure of the reproductive effort on the part of the wolves; in other words, mortality of pups—this, occurring in the seeming face of plenty—violates a few of our normal concepts of population dynamics. Have you any suggestions as to the cause of the mortality?

MR. RAUSCH: I probably should say no.

It seems to me that the critical time for a wolf population is shortly after pupping or when the pups are still around the den. The food must be available in good supply at that time. During the period that this wolf population was building up, the snowshoe hare was also extremely abundant. They crashed in about 1965. Pup production did go down thereafter.

I am not implying that they are dependent upon snowshoe hare, but at times hares are a significant portion of the wildlife. It is just an idea.

MR. C. T. BLACK (Michigan): You refered to developments on the North or Arctic Slope that might affect the future of the wolf in Alaska. What are these developments and what are the portents for the future of the wolf?

MR. RAUSCH: The developments concern extractions of what some people believe to be one of the largest oil deposits in the world, and it is proceeding at a fairly rapid rate. Wolves there are extremely vulnerable to aircraft hunting and other forms of hunting. They exist on true tundra, and they have been depressed in this area before. There are now thousands of people working up there; there may be more thousands.

WINTER DISTRIBUTION OF BLACKBIRDS AS RELATED TO CORN DAMAGE CONTROL IN BROWN COUNTY, SOUTH DAKOTA

JOHN W. DE GRAZIO, JEROME F. BESSER, AND JOSEPH L. GUARINO
Bureau of Sport Fisheries and Wildlife, Denver Wildlife Research Center, Denver, Colorado

Blackbird damage to ripening corn in late summer is a widespread and locally serious agricultural problem in the United States. Since 1960, Denver Wildlife Research Center personnel have been testing methods to reduce this problem in a 94-square-mile study area in Brown County, South Dakota. Peak populations of 1 million to 2 million blackbirds roost and feed in this area during August and September and cause annual losses of more than 30,000 bushels of corn (De Grazio, 1964). Of the blackbird species involved in the problem, northern migrant red-winged blackbirds (*Agelaius phoeniceus*), are primarily responsible for the damage. Most yellow-headed blackbirds (*Xanthocephalus xanthocephalus*), including summer residents and northern migrants, move south in August during the early part of the damage season, and common grackles (*Quiscalus quiscula*), immigrate from the north into the area in September during the latter part of the damage season. These two species are present in moderate numbers and cause some of the damage. Brewer's blackbirds (*Euphagus cyanocephalus*), and brown-headed cowbirds (*Mo-*

lothrus ater), are never abundant in the area and their contribution to the problem is negligible.

Three approaches to solving the problem have received major thought: protection of the cornfields being damaged, reduction of the problem populations at roosts in Brown County in late summer, and reduction of the problem populations at their distant winter roosts. For on-site protection in this area, mechanical frightening devices have provided some reduction in damage (De Grazio, 1964), and chemical frightening agents show excellent promise for efficiently and economically protecting all fields within the daily feeding range of birds from these troublesome roosts in Brown County (Woronecki *et al.,* 1967). Our efforts to reduce the number of birds at these late-summer roosts have not been very productive because, with extensive areas of suitable roosting cover and low roosting densities, roosts averaged only about 500 birds per acre of marsh. Therefore, the third approach, control at distant winter roosts, seemed more feasible, since wintering densities of more than 1 million blackbirds per acre have been reported (Neff and Meanley, 1957).

To determine the feasibility of applying control at winter roosts to reduce the populations of blackbirds that damage corn in late summer in Brown County, it was necessary to determine the location and densities of these roosts. This paper presents the information we gathered on this question.

METHODS

An analysis was made of all redwing, yellowhead, and grackle recoveries in winter (December, January, and February) from banding in Brown County during the corn damage season (August and September). Most of these recoveries resulted from about 27,000 blackbirds (9,656 redwings, 11,997 yellowheads, and 5,425 grackles) banded by Denver Center personnel and cooperators from 1961 through 1966; only three were from birds banded before 1961.

Information on winter roosts was obtained from national winter roost surveys conducted from 1960 through 1965 by personnel of the Patuxent and Denver Wildlife Research Centers and cooperators (Neff 1963, 1964; Meanley and Webb 1963, 1966). In estimating the number of birds and roosts implicated in the Brown County problem, all birds at reported roosts within 30 miles of a recovery site were included. In some instances, more than one roost was located within this range. The 30-mile distance was chosen because of our observations that blackbirds seldom travel farther in their daily feeding flights. When a recovery site was more than 30 miles from the nearest known roost, we assumed at least one roost of unknown size was present, and classified it as an unreported roost.

RESULTS AND DISCUSSION

There were only 47 winter recoveries of blackbirds banded during the corn damage season in Brown County, including 22 redwings, 11 grackles, and 14 yellowheads. They were recovered in 11 states in the United States and 5 states in Mexico (Fig. 1). Twelve redwings were recovered in Texas; two each in South Dakota, Kansas, and Louisiana; and one each in Iowa, Missouri, Nebraska, and Oklahoma. Three grackles each were recovered in Texas and Louisiana, two each in Arkansas and Mississippi, and one in Iowa. Five yellowheads were recovered in the state of Jalisco, four in Guanajuato, two in Durango, and one each in Chihuahua and Michoacán. A single yellowhead was also recovered in Florida, an unusual record (Guarino, 1967). At least 20 of the 22 redwings and 9 of the 11 grackles were recovered from different roosts. These few recoveries may not show the true winter range of the Brown County population, but because most of them (94 percent) resulted from a relatively short period of banding (6 years), and the recovery period was restricted to three months, their wide distribution suggests that the winter range is quite extensive.

Only 19 of the 47 recoveries (about 40 percent) were made within 30 miles of roosts reported in the surveys. There were 30 reported roosts containing an estimated 58.5 million blackbirds within the daily feeding range of these 19 blackbirds. About 60 percent of the recoveries were in areas with unreported roosts. Eleven of the 22 redwings were recovered near 18 reported roosts that contained 19.5 million birds. Eleven were recovered near unreported roosts. Thus about 50 percent of the population of the most important species damaging corn in Brown County were using roosts that were not reported in national surveys. Eight of the 11 grackles were recovered near 16 reported roosts that contained 40.8 million birds. Two of the grackles were recovered in a complex of 4 roosts in Louisiana where one redwing was recovered. Therefore, there is an overlap in the number of birds in these roosts when totalled by species. Only 3 grackles were recovered near unreported roosts. All 14 yellowheads were recovered near unreported roosts, since no roost surveys have ever been made in Mexico.

The number of winter roosts and birds known to be implicated in the Brown County problem increases each year as additional recoveries are made. A realistic estimate of the total number of roosts and birds that may eventually be involved cannot be made from information now available. However, from unpublished winter roost data that we have collected throughout the West during the past several years and from the numbers of blackbirds reported in the Christmas Bird Counts (Audubon Field Notes, 1962-1966), we suspect that there are

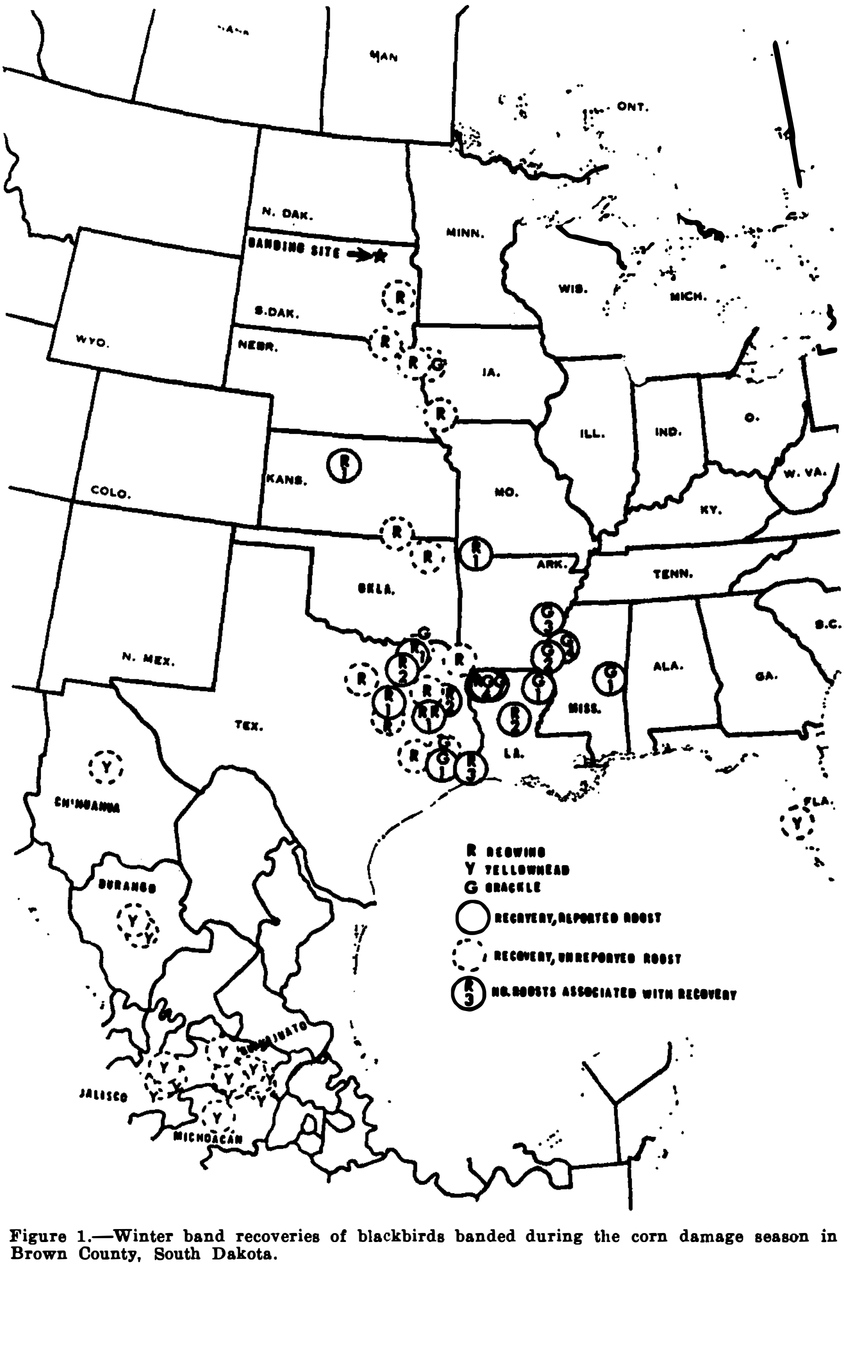


Figure 1.—Winter band recoveries of blackbirds banded during the corn damage season in Brown County, South Dakota.

numerous unreported roosts well scattered throughout the wintering range of the Brown County problem birds. For example, for Texas, Neff (1964:17) reported only 14 roosts, each containing from 2 thousand to 4 million birds. Meanley and Webb (1966:11-12) reported 17 roosts, each with at least 1 million birds and one with about 15 million, but at least 8 of these roosts had already been reported by Neff. Our unpublished data show at least 70 unreported roosts in Texas, with populations ranging from less than a thousand to 1 million birds. Thus, no more than a quarter of the roosts in that state have been reported—probably much less.

CONCLUSIONS

Analysis of banding data show that blackbirds responsible for damage to ripening corn in Brown County, South Dakota, are widely dispersed during the winter and that many occur in unreported roosts. Thus, from these preliminary data, it appears that damage control by treatment of distant winter roosts would be difficult and that the most practical solution to the problem is to concentrate on protection of the cornfields at the damage site.

LITERATURE CITED

De Grazio, J. W.
1964. Methods of controlling blackbird damage to field corn in South Dakota. Proc. 2nd Vertebrate Pest Control Conf., Anaheim, Calif.: 43-49. Univ. of Calif., Davis, Agri. Ext. Service, 160 p.

Guarino, J. L.
1967. Dakota-banded yellowhead recovered in Florida. Inland Bird Banding Association News, 39(6): 160.

Meanley, B., and J. S. Webb
1963. Distribution and ecology of blackbird and starling roosts in Eastern United States. Unpub. Prog. Rep. U. S. Fish and Wildlife Service, Patuxent Wildl. Res. Cent., Laurel, Md., 23 p. (mimeo).

———
1966. Distribution and ecology of blackbird and starling roosts in Eastern United States. Unpubl. Prog. Rep. U. S. Fish and Wildlife Service, Patuxent Wildl. Res. Cent., Laurel, Md., 13 p. (mimeo).

Neff, J. A.
1963. Distribution and ecology of blackbird and starling roosts in Regions 1, 2, and part of 3. Unpubl. Prog. Rep. U. S. Fish and Wildlife Service, Denver Wildl. Res. Cent., Denver, Colo., 21 p. (mimeo).

———
1 964 Distribution and ecology of blackbird and starling roosts in Regions 1, 2, and part of 3. Unpubl. Prog. Rep. U.S. Fish and Wildlife Service, Denver Wildl. Res. Cent., Denver, Colo., 18 p. (mimeo).

Neff, J. A., and B. Meanley
1957. Blackbirds and the Arkansas rice crop. Ark. Agri. Exp. Sta. Bull. 584, 89 p.

Woronecki, P. P., J. L. Guarino, and J. W. De Grazio
1967. Blackbird damage control with chemical frightening agents. Proc. 3rd Vertebrate Pest Control Conf., San Francisco, Calif.: 54-56. Univ. of Calif., Davis, Agri. Ext. Service, 178 p.

DISCUSSION

DR. OLIVER HEWITT (Cornell University): How serious was the corn damage in this area before your treatment?

MR. DE GRAZIO: We have about five years' of pretreatment data, and I am speaking of the 94-section area that I mentioned, which consisted of about 8 to 9000 acres annually. Based on damage appraisal and surveys that we made during the years prior to control, it averaged 2.7 bushels per acre.

We weighted some by populations that varied from year to year. Although it is somewhat stable, it varied from 1 to 2 million birds per year.

MR. JIM BURBANK (Tennessee Valley Authority): Mr. DeGrazio, we have a problem in the Tennessee Valley with starlings especially, concentrating on winter roosting areas.

Have you had any experience in trying to control birds in a situation like that? For instance, we are thinking spraying during the wintertime to control this population.

MR. DE GRAZIO: We have had little experience with spraying contact poisons in roosts. However, the Patuxent Wildlife Research Center is doing research in that area.

The only roost control we have done is by baiting staging areas. Usually in some areas, starlings have an area where they stage prior to going to roost at night. We found in some areas in the West that we can bait these staging areas with a toxicant; DRC-1339 is one. We have had paramount success in some areas.

MR. L. C. HOLCOMB: (Creighton University, Nebraska): In light of what you said about the dispersal of redwing blackbirds on their staging grounds, and in light of what you said about the seemingly infeasibility of removing large numbers that are doing the damage by spraying winter roosts, are you at odds with what the Patuxent research group is doing? I know a great deal has been done on trying to develop chemicals that will kill birds at their wintering grounds.

MR. DE GRAZIO: Maybe we can clear the air on this.

We are doing some spraying of birds in roosts in the wintertime, and we are not at odds with Patuxent. We are following their research and, if they come up with a good technique, we may be able to employ that in some of our roosting areas in the West.

The only point I am trying to make is that, for our situation in South Dakota, we feel that baiting corn fields seems much more feasible than traveling south and treating large numbers of roosts.

However, each situation is different. So I don't think we can come up with a universal technique for all damage situations. It is going to take a variety of techniques, and roost control is certainly one of them.

MR. HOLCOMB: One further question. In view of the placidity of this species and its widespread geographic availability, it would seem to me, after doing some basic reproductive physiological and population studies and knowing something about the numbers of subadults and the adults in the group, that one should rather put more emphasis on an embryocide, or sterilant. The birds that are doing the majority of damage are birds of the year, and they need very few adult birds to set an example for them.

Yet, the number of times the females will nest or renest, and indeed sometimes renest for as many as five times, seems to show that they are well able to bring the population back up to what would be a destructive level from your studies.

MR. DE GRAZIO: I have nothing to add to that. I can't agree with you more.

FROM THE FLOOR (Illinois): It seems the cost of this is far in excess of a few bushels of corn.

Do you have data as to what your poison has done to other birds, or other forms of wildlife, aftereffects or residual effects, and what happened to the natural controls that existed before you got into the problem?

MR. DE GRAZIO: We have quite a bit of information on hazards to other species, but with this one particular chemical that I mentioned we found that, using dilution rates of one part treated to 99 parts untreated, we were able to get by doves and pheasants that feed in cornfields, primarily because these are much larger than blackbirds. Blackbirds weigh around 60 grams, and doves probably twice and pheasants about ten times that size. So I think we are quite safe so far as other bird species are involved.

FROM THE FLOOR (Tennessee): There are serious problems associated with winter roosts. We have one there in east Tennessee in which the blackbirds are consuming a vast amount of seed in one cattle feed yard in the immediate vicinity of the roosts. We feel if direct control could be done on this roost, it would alleviate the problem for us. It is a rather serious magnitude in terms of the value of feed a day. There, direct control has been unsuccessful.

EFFECTS OF NUTRITION AND CLIMATE ON SOUTHERN DEER

HENRY L. SHORT[1]
U. S. Forest Service, Nacogdoches, Texas; and

JOHN D. NEWSOM, GEORGE L. MCCOY, AND JAMES F. FOWLER
Cooperative Wildlife Research Unit, Louisiana State University, Baton Rouge

White-tailed deer (*Odocoileus virginianus*) in southern upland forests tend to be small and occur at low densities. The present study was undertaken to determine whether low-quality diet and climatic stress are contributing causes. Growth and food-consumption patterns throughout 3- and 2-year periods were observed for captive deer fed highly nutritious rations and rations with nutrient content similar to that of upland forage.

METHODS

In the first part of the study, food consumption and body weight were monitored for captive deer fed a nutritionally adequate ration from January, 1966 through December, 1968. Five male and five female fawns were captured from upland ranges in Louisiana and bottle-fed. After they were weaned, the fawns were placed in individual pens with 144 square feet of floor area under a protective roof. The composition of the control ration fed to these deer is shown in Table 1. Two of the five bucks died from injuries sustained in the pens—one during October 1967 and the second during November 1968. Does were bred during February, 1968, when they were about 32 months old.

In the second part of the study, made throughout 1967 and 1968, different rations were provided during each of the four seasons. The rations were formulated to approximate the nutrient contents of vegetation that wild deer would encounter in upland forests. The composition of seasonal rations was based on nutrient analyses of vegetational components of southern forests listed by Lay (1957), Causey (1964), and Caillouet (1960). These experimental rations were usually more fibrous and less nutritious than the control ration used in the first part of the study (Table 1). The variable diets were pellets formulated from soybean-oil meal, corn-feed meal, beet pulp, purified cellulose, corn oil, and mineral and vitamin supplements. Seven fawns from the Delta National Wildlife Refuge, Plaquemines Parish, and three from upland habitats in Louisiana (five of each

[1]Research wildlife biologist at the Wildlife Habitat and Silviculture Laboratory, which is maintained by the Southern Forest Experiment Station in cooperation with Stephen F. Austin State College, Nacogdoches, Texas.

sex) were bottle-fed until weaned, penned as were the first group, and fed a commercial ration from early autumn through January, 1967. They were then given the experimental rations. One buck died in September, 1967.

Food and water were offered *ad libitum* to all captive deer. Moisture content of foods was about 10 percent. Food consumption of each deer was measured daily, and the animals were weighed weekly. Throughout this paper, rates of food consumption are expressed as g food (air-dry weight)/day/kg body weight$^{3/4}$. This measure of food consumption is readily interpretable with regard to the metabolic requirements of homeotherms.

Differences in rates of food consumption for different sex-age classes and feeding groups were compared with t tests. Rates of gain for different groups of deer during spring and summer were compared by calculating regression equations and comparing the slopes with F tests.

Body weights of deer on each ration were compared with those reported by the Louisiana Wild Life and Fisheries Commission (1966) for deer shot from upland habitats with infertile soils and from bottomland habitats with good soils.

Temperature and humidity were recorded at the deer pens throughout 1967 with a hygrothermograph. Temperature-humidity index (T.H.I.) values were calculated with the formula listed in Johnson *et. al.* (1962).

RESULTS

Bucks

Body weights and rates of food consumption of bucks fed adequate and restricting rations are summarized in Figure 1. The average daily rates of consumption did not differ significantly for bucks 7 to 18 months old fed the control and those 8 to 18 months old fed the experimental rations (Table 2). Young bucks on the control ration increased their body weight by at least 5 percent per month during the eight months from February through September, while those on experimental diets gained at that rate only from April through August.

Bucks on restricting rations lost 15 percent of their late-summer body weight between October and February. Bucks on the control ration lost weight only from November through January, and the decline amounted to only 11 percent of early-autumn body weight. Young bucks on the control ration gained 8 kg more and lost 1 kg. less weight than did those on experimental rations—a net gain of 9 kg.

Rates of food consumption for two- and three-year-old bucks on the

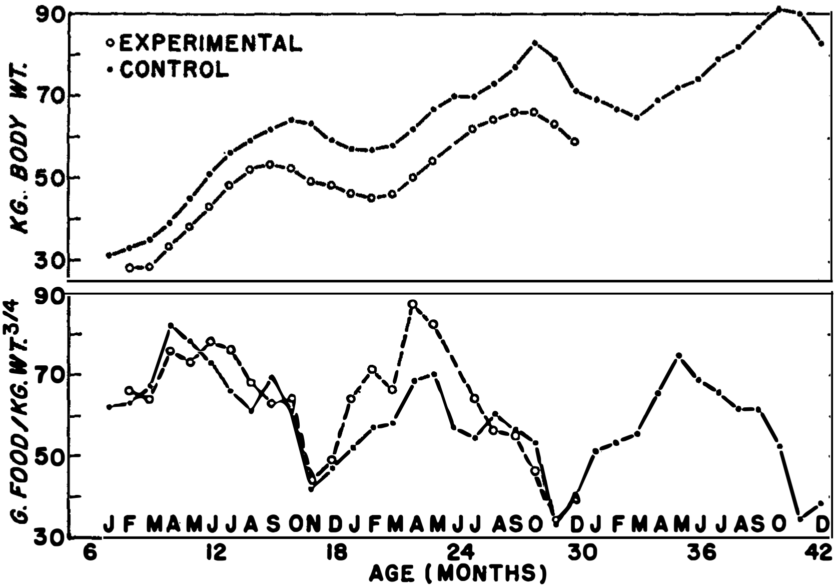


Figure 1. Body weights and rates of daily food consumption for bucks fed control and experimental rations.

control ration increased from November lows to very high April-May levels, diminished in midsummer, increased somewhat in late summer or early autumn, and decreased sharply in midautumn, during the rut. Food consumption of young bucks on the experimental rations did not increase appreciably in early autumn.

Food consumption of control bucks was below maintenance during their second winter, and they lost 22 percent of their early-autumn body weight. High rates of food consumption during their second and third springs allowed bucks to regain weight lost during the previous autumn-winter and provided nutrients and energy for antler development. Only modest gains in body weight occurred during their second and third years (19 and 8 kg., respectively). Average daily food consumption was significantly less for old bucks than for young ones (Table 2).

TABLE 1. COMPOSITION OF RATIONS FED TO CAPTIVE DEER

Ration	When fed	Crude protein	Crude fat	Crude fiber	Calcium	Phosphorus
		Percent of dry matter				
Control	Annual period	14.9	4.2	7.4	1.4	0.44
Experimental	April–May	16.6	3.7	16.8	0.88	0.25
	June–August	12.0	4.3	21.1	1.15	0.18
	September–December	8.6	6.3	20.4	0.88	0.16
	January–March	8.2	4.5	32.5	1.19	0.11

TABLE 2. FOOD CONSUMPTION AND WEIGHT GAIN, BY SEX-AGE CLASS AND RATION

Ration and sex-age class	Food consumption Mean ± SE for annual period	Increase during period of rapid weight gain or recovery	
		Age	Rate
	g/day/kg(BW)¾	*Months*	*kg/month*
Control			
Female (7–18 months)	66.4 ± 2.35^{a}[1]	9–17	$2.09^{d,e}$
Female (19–30 months)	49.3 ± 1.56^{d}	21–29	0.92^{f}
Female (31–42 months)	$51.4 \pm 2.44^{c,d}$[2]	33–37 (pregnant)	1.77^{e}
Male (7–18 months)	64.4 ± 3.29^{a}	9–16	$4.37^{a,b}$
Male (19–30 months)	$54.9 \pm 2.98^{b,c}$	21–28	3.17^{c}
Male (31–42 months)	$56.4 \pm 3.45^{b,c}$	33–39	$3.64^{b,c}$
Experimental			
Female (8–18 months)	$60.5 \pm 2.19^{a,b}$	8–16	$2.02^{d,e}$
Female (19–30 months)	$56.7 \pm 2.87^{b,c}$	21–33	$3.02^{c,d}$
Male (8–18 months)	65.5 ± 3.24^{a}	10–14	4.85^{a}
Male (19–30 months)	$60.5 \pm 4.98^{a,b}$	21–26	$3.73^{b,c}$

[1] Within a column, values followed by the same letter do not differ significantly ($P < 0.05$).
[2] Does not include food consumption for September through November, when fawns were with females.

Throughout the year, bucks from 19 to 30 months old ate control and experimental rations at similar rates. Those on the experimental ration utilized their feed less efficiently, however, as they gained 4 kg. less weight.

Does

Young control-fed does (7 to 18 months of age) ate at high levels from January through June and from September through October, and at diminished rates in midsummer and during late autumn and early winter. Young does on experimental diets ate the favorable spring ration at high levels and the other seasonal rations at nearly constant rates, except for a low consumption during December (Fig. 2). Young does on the control and experimental rations had similar rates of daily food consumption (Table 2). Those fed the control ration increased their body weights by 5 percent per month during 8 of the first 10 months of the calendar year, while those fed experimental rations made such gains during only 4 months. Because of the longer period of weight gain, control-fed does had a net gain of about 3 kg. more than did those on experimental rations. Minor weight losses were recorded during late autumn and winter for both groups of young does.

Weights of does 19 to 30 months old did not differ by ration. These animals were 6 to 7 kg. heavier than they had been as yearlings. Those on the control ration required significantly less food for maintenance than they had as growing yearlings (Table 2). Does 19 to 30 months old on the experimental rations had a significantly higher daily food consumption rate throughout the year than did control-fed deer. This increased voluntary food consumption must have been associated with a lowered apparent digestibility of the experimental food, because

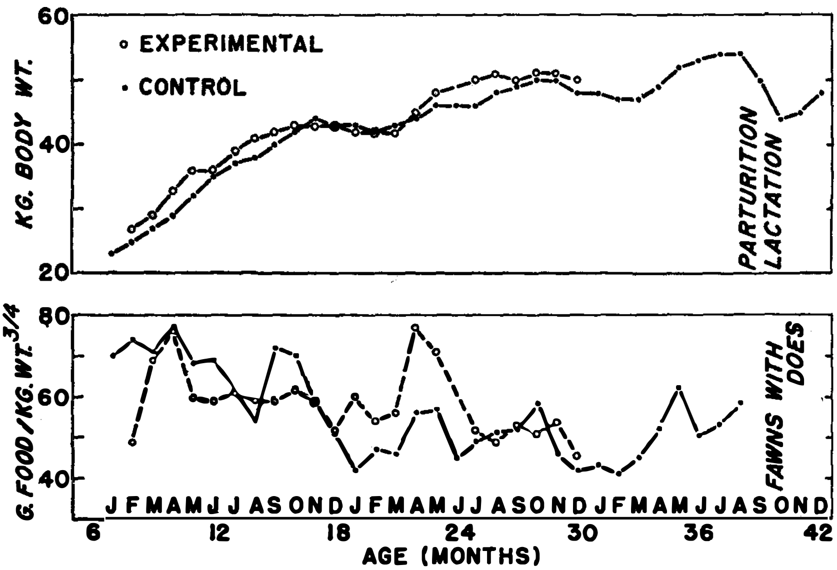


Figure 2.—Body weights and rates of daily food consumption for does fed control and experimental rations.

experimental deer did not outperform control deer. Control-fed does ate at relatively high rates during spring and early autumn, and at reduced rates during midsummer and late autumn and winter. Gradual weight gains were recorded throughout the spring and summer. Does on experimental diets ate at high rates during April and May, and at lower, nearly constant rates during the other months. Most of their weight increase occurred during April and May, and no measurable weight changes occurred from July to December.

Control-fed females were bred when they were 32 months old. Three sets of twins and one single fawn were born in August and September, 1968. The pattern and rate of food consumption for pregnant 3-year-old does was similar to that for the same deer when they were 2 years old. Rapid rate of weight gain of pregnant does during the spring and summer reflects the development of fetuses.

Body weight and food consumption data for the postpartum and lactation periods are fragmentary because of difficulty in gathering data without disturbing or possibly harming the animals. One doe lost 12 percent of her immediate prepartum body weight during the week she gave birth to a fawn and an additional 12 to 14 percent during the 10-week lactation period. During early lactation she consumed food at a rate about 15 percent higher than that of a barren doe of the same age. Another doe lost 30 percent of her immediate prepartum weight from parturition until her twin fawns were weaned. Her average food consumption during the first 14 days after parturition was about 30 percent greater than that during a 10-day period immediately prior to giving birth.

Lactating does require a large amount of nutritious food. The doe draws extensively upon body reserves, at least during early lactation. Does continue to consume foods at high rates after lactation ceases and quickly recover, even in winter, if adequate foods are available (Fig. 2).

Had these lactating deer been feeding on the autumn or winter experimental ration, fawn survival and the rate of recovery of physical condition would possibly have been reduced because of protein and mineral deficiency.

Comparison with Range-Killed Deer

Data about the penned deer in the current study were placed in perspective by comparing them with published records on white-tailed deer killed in Louisiana game-management areas (Louisiana Wild Life and Fisheries Commission, 1966).

Wild deer from upland habitats were considerably lighter than both deer from bottom-land areas and those fed experimental rations (Table 3). Captive bucks on the control ration were 45 percent heavier and does 20 percent heavier than the upland deer. Captive deer fed the experimental rations were about 20 percent heavier than upland deer. Bottomland deer had weights somewhat similar to those of deer on control rations.

Climatic Stress

Food consumption of control-fed bucks and nonpregnant does 19 to 30 months old was lower in June and July than in late spring and in late summer and early autumn (Fig. 3). This decline in consumption occurred at T.H.I. levels of 77 to 78—when average ambient temperature was 27°C and average relative humidity was 75 percent. Food consumption increased in late summer or early autumn, when T.H.I. values decreased. Some of the late-summer increase may also be attributed to acclimitization of deer to summer conditions.

Diminished voluntary food intake at high ambient temperatures has also been observed for domestic ruminants (Johnson and Yeck, 1964). A reduction in food intake at higher temperature, coupled with an increased energy expenditure for heat dissipation, may cause reduction or cessation of body growth (Hafez, 1967).

Declines in milk production are noticeable at ambient temperatures near 27°C, especially when humidities are high (Johnson *et al.*, 1962). This reduced milk production may be due to diminished food

TABLE 3. ANTLER POINTS AND BODY WEIGHT OF DEER FED CONTROL AND EXPERIMENTAL RATIONS IN CAPTIVITY, AND OF DEER SHOT IN 1965 ON UPLANDS AND BOTTOM LANDS IN LOUISIANA[1]

Item	Bucks				Does	
	Antler points		Weight		Weight	
	1½ years	2½ years	1½ years	2½ years	1½ years	2½ years
	No.		*kg*		*kg.*	
Captive						
Control ration	5.4	8.2	64.2	82.6	43.6	49.9
Experimental ration	3.7	6.3	52.4	66.3	43.2	50.7
Free						
Upland	2.6[2]	6.4[2,3]	43.6	57.2[3]	36.6	41.7[3]
Bottom land			54.4	80.2[3]	46.6	50.1[3]

[1] Weights of shot deer from Louisiana Wild Life and Fisheries Commission (1966).
[2] Data for both uplands and bottom-land deer from Newsom *et al.* (1968).
[3] Includes animals more than 2½ years old.

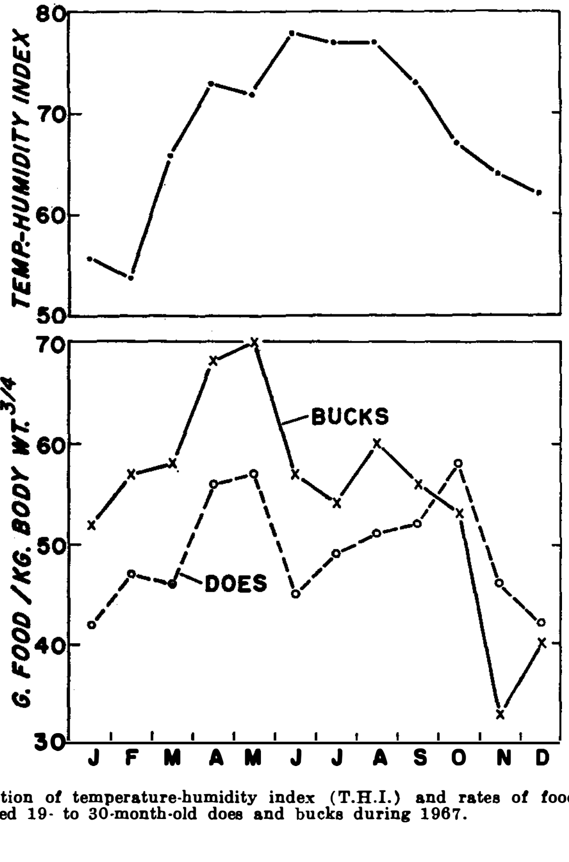


Figure 3. Relation of temperature-humidity index (T.H.I.) and rates of food consumption of adequately fed 19- to 30-month-old does and bucks during 1967.

intake as well as other physiological mechanisms related to lactation (Hafez, 1967).

DISCUSSION

Deer from upland habitats in the South are smaller than those from bottom lands. Most upland sites have highly leached and infertile soils, which are moderately to strongly acid and low in both organic matter and mineral nutrients. Except during spring growth, upland vegetation is usually fibrous, and low in protein and minerals essential for good body growth. Deer eating rations similar in composition to foodstuffs available in upland habitats gain weight over a shorter period in spring and early summer, and lose more weight during autumn and winter, than deer on a more nutritious diet.

When fed nutritious rations, deer from upland habitats have good growth potential. Yearling bucks weighed over 64 kg., 2½-year-old bucks over 82 kg., and 3½-year-old bucks over 90 kg. Antler configurations for yearlings and deer 2½ and 3½ years old averaged 5, 8, and 9 points, respectively. Deer from fertile bottomland habitats of the Mississippi Alluvial Plain had weights somewhat comparable to those of deer fed high-quality rations in the present study.

Dietary deficiencies in upland habitats probably limit deer numbers as well as their weight. Feeding studies with captive deer indicate that substantial fawn losses occur when does are fed deficient diets. In Missouri, does fed rations containing 7 to 11 percent protein throughout the year lost 25 percent of their young fawns (Murphy and Coates, 1966), and, in Michigan, does fed poor rations in winter and adequate diets in spring lost 35 percent of their fawns (Verme, 1962).

High ambient temperatures can directly affect survival of neonates (Hafez, 1967). Lactation abilities of does and fawn survival should also be affected by the diminished nutrient quality of foods (Short and Harrell, 1969) and the adverse affects of climatic stress on voluntary food intake during the summer. If ample energy and protein sources are not readily available in autumn, does may not be able to recover condition before the breeding season and winter. What effect this may have on subsequent fawn crops is unknown. If good quality foods are not abundant, newly weaned fawns with relatively high metabolic requirements will fare poorly. Furthermore, nutritional stress at all seasons will generally reduce the resistance of deer to other debilitating factors, such as parasites.

LITERATURE CITED

Caillouet, C. W.
1960. Nutrient content of some seeds and fruits utilized as food by wildlife in Louisiana. M.S. thesis. Louisiana State University, Baton Rouge.

Causey, M. K.
1964. Nutritional analysis and seasonal variation of some herbaceous deer browse plants in the pine-hardwood areas of Winn and Union Parishes, Louisiana. M.S. thesis. Louisiana State University, Baton Rouge.

Hafez, E. S. E.
1967. Bioclimatological aspects of animal productivity. World Rev. Anim. Prod. 3(14): 22-37.

Johnson, H. D., A. C. Ragsdale, I. L. Berry, M. D. Shanklin, and S. McLarney
1962. Environmental physiology and shelter engineering with special reference to domestic animals. LXVIII. Age and temperature effects on TDN water-on milk production of Holstein cattle. Mo. Agr. Exp. Sta. Res. Bull. 791, 39 pp.

——— and R. G. Yeck
1964. Environmental physiology and shelter engineering with special reference to domestic animals. LXVIII. Age and temperature effects on TDN, water-consumption and balance of dairy calves and heifers exposed to environmental temperatures of 35 to 95°F. Mo. Agr. Exp. Sta. Res. Bull. 865, 37 pp.

Lay, D. W.
1957. Browse quality and the effects of prescribed burning in southern pine forests. J. Forest. 55: 342-347.

Louisiana Wild Life and Fisheries Commission.
1966. Eleventh biennial report 1964/1965. La. Wild Life and Fish. Comm. 274 pp. New Orleans.

Murphy, D. A. and J. A. Coates
1966. Effects of dietary protein on deer. Trans. N. Amer. Wildlife and Natur. Resources Conf. 31: 129-138.

Newsom, J. D., H. L. Short, J. F. Fowler, and G. L. McCoy
1968. Study shows effects of nutrition on growth of deer. La. Agr. 12(1): 4-5.

Short, H. L. and A. Harrell
1969. Nutrient analysis of two browse species. J. Range Manage. 22: 40-43.

Verme, L. J.
1962. Mortality of white-tailed deer fawns in relation to nutrition. Proc. 1st Natl. Deer Disease Symp.: 15-28, 37-38.

DISCUSSION

DISCUSSION LEADER DR. COWAN: We would have to agree that the work reported here is just one more piece in the whole story that poor soil produces poor populations and poor animals.

MR. STANLEY LOGAN (New York): You are familiar with the foods of our white-tailed deer in New York State. Are these white-tailed deer in Louisiana and the same strains as those in the northern United States?

DR. SHORT: No, they are a different subspecies.

MR. LOGAN: I think you mentioned that does would fawn after 32 months; is that right?

DR. SHORT: That the does were bred at 32 months of age. This is arbitrary on my part.

MR. LOGAN: Is there a reason for that? I know in New York State, even fawns that are born this year, possibly a good percentage of them, would be bred before winter sets in.

DR. SHORT: The only reason we held off to 32 months, is that we wanted to have two years of normal data before we complicated the picture with productivity.

MR. LOGAN: As far as the food is concerned, you indicated the full nutrient required and the subration of nutrients. What do your plants lack in the way of nutrients in the natural forage?

DR. SHORT: In the South, our forage is hardened off in mid-summer. So after mid-summer, we have a fiber problem. It is considerable.

Much of the protein and mineral content of the forages, which we have measured in the spring, has been diluted by various metabolic activities of the plants. After midsummer, we find the protein, and especially phosphorus content of these forages quite deficient.

Range studies throughout the South have shown that unless adequate supplementation occurs throughout the autumn and winter, productivity will fall off to an extremely low balance. This situation also occurs in the deer herd. We are dealing with a forage which after mid-summer is very deficient in protein and phosphorus.

MR. LOGAN: In Mississippi and Louisiana, would shrubs and berries and nuts be comparable at all to forage in Florida?

DR. SHORT: I think you can generalize about the quality of some of these food stuffs which will hold throughout the South.

MR. WALLACE MACGREGOR (California): You spoke of the decreased mortality. Did you have any evidence in animals on deficient diet of decreased production of births, or was this mortality of fawns after and following birth?

DR. SHORT: I believe I am safe in being evasive in answering your question. Production and mortality figures for deer in the South are very hard to come by and are not extensive enough to provide you with a thorough answer.

EFFECTS OF QUALITY ON FOOD INTAKE IN DEER

JULIUS G. NAGY,[1,2] THOMAS HAKONSON,[3] AND KIRVIN L. KNOX[2]
Colorado State University, Fort Collins

Thirty years ago wildlife management frequently faced the problem of overpopulated deer ranges. Today we experience the increasing pressure of the human population explosion. One consequence of this is an increased hunting pressure on big game and the realization that in the future more intensive management of big game will be necessary. Wildlife researchers therefore, have, become interested in the physiology and nutrition of deer, since future intensive deer management will depend largely on results of today's research.

How important this knowledge is and what could happen if the needed information is lacking might be illustrated with many unsuccessful winter feeding programs of the 1930's and 1940's. These programs are still vivid in the memories of those who had to execute them reluctantly due to public pressures. In part, these programs disregarded basic principles of ecology and population dynamics, but it is true that we did not know much then about the physiology and nutrition of deer. The science of ruminant nutrition with the full realization of the importance of rumen microorganisms and their end products of fermentation originated in the 1940's.

Our knowledge of ruminant nutrition increased tremendously during the last few decades. More recently wildlife researchers have begun to report information on wild ruminant nutrition. With more intensive use of big game in the future, mass starvation of deer will seem more intolerable than ever before. The possibility exists, whether we like it or not, that we may have to consider supplemental feeding programs for portions of our deer herds during certain unusually hard times. Game departments have begun already exploring the possibilities of such programs for the future. The success of any such operation will depend not only on the knowledge of general ruminant nutrition but on thorough familiarity with the characteristic physiological and nutritional requirements of wild deer. We have to know more about problems such as physiological reasons which determine

[1]Department of Fishery and Wildlife Biology
[2]Department of Animal Science
[3]Department of Radiology and Radiation Biology

and characterize natural food selection of deer. The specific nutritional requirements of rumen microorganisms, their fermentation patterns and contribution of microbial end products to the energy and nutritional requirements of the host, and the dynamics of passage rates of ingesta and turnover rates of nutrients in deer are among the types of information needed.

The basic principles of ruminant nutrition certainly apply to deer. Evidence, however, is accumulating that deer, like other ruminants, have their own characteristic physiological and nutritional requirements. Those requirements have to be investigated thoroughly before precise relationships can be established between deer and their environment. Our paper, therefore, will discuss some of the known physiological and nutritional differences between domestic and wild ruminants, especially deer of the genus *Odocoileus* and will point out those areas in which our knowledge is still uncertain or lacking.

Though both are true ruminant animals, cattle and deer long ago developed quite different feeding habits. Cattle became grazers specialized in consuming grasses. The consequence of this specialization was that cattle received a highly digestible and nutritious food during spring and early summer but, later in the season, as grasses dry, their diet is higher in cellulose. Cellulose digestion is a time-consuming process for rumen microorganisms. Therefore, cattle developed a voluminous rumen to accommodate large amounts of roughage to obtain enough energy from the slow process of cellulose digestion and other microbial breakdown processes. Cattle developed, accordingly, a large body to accommodate this spacious fermentation vat which can contain as much as 150 liters of ingesta (Sisson and Grossman, 1953). The rumen contents of a cow make up 12-13 percent of the total body weight of the animal (Thomas *et al.*, 1961). Cattle consequently leave the work of digestion mainly up to the rumen microorganisms when they consume a diet high in roughage.

Most deer, on the other hand, developed differently. Their diet, at least that of American Odocoilids, consists primarily of forbs and browse, the latter predominating when herbaceous forage is unavailable. Although still subject to seasonal changes, browse does not vary in nutritional value as much as grasses. Usually deer are able to select from season to season those browse plants of the highest quality. Except on severely overgrazed range, usually only the tips of the stems are taken. According to Cowan (1968) black cherry buds contain 25 percent crude protein, the terminal one-inch portion of the twig 17, the next portion 15, and the next six to nine inches contain less than 10 percent crude protein. The same tendency was observed by Bailey (1967) in witch-hobble twigs. The crude protein content of the current annual growth of some principal browse species in Colorado during winter was 8 to 11 percent and the crude fiber content was between 17 and 30 percent (Dietz, *et al.*, 1962). On the other hand, dry, weathered, wild, bromegrass contains three percent crude protein and 32 percent crude fiber (Morrison, 1949). Thus deer were probably not exposed to a diet as high in cellulose as cattle and consequently did not have to develop such a large rumen. Short (1963) presented data on weight of rumen contents compared with total body weights of white-tailed deer. According to his data the weight of deer rumen contents is between 2.5 and 6.8 percent of body weight while the same for cattle was about 13 percent (Thomas, *et al.*, 1961).

With a larger body size cattle have a lower metabolic rate than deer. Basal metabolic rate is a function of body weight in most animals (Kleiber, 1932). It has been shown by Silver *et al.*, (1959) that this relationship holds true for deer also. For this reason deer must utilize more energy per unit time and weight than cattle.

The concentrations of short-chain fatty acids, the principal rumen microbial end products of fermentation, are similar in cattle, sheep and deer rumen contents. Reported in the literature are values ranging from 57 to 184 millimoles per liter (mM/1) of rumen contents for cattle and sheep (Annison and Lewis, 1959); and 93 to 125mM/1 for wild deer (Nagy *et al.*, 1967). Percentage distribution of fatty acids in the rumen of free-grazing cattle were 67.5, 18.2, 11.1, 3.2 (Balch and Rowland, 1957), while for deer 65.9, 20.4, 11.4, 2.2, (Short *et al.*, 1966) for acetate, propionate, butyrate and higher acids, respectively. Controlled experiments using the same diet would seem desirable for valid comparisons. One problem with both Short's and our data is that we obtained rumen content samples several hours after death of the animals. Rumen fermentation activity, of course, will go on after death, while absorption of end products stops. This might increase the total concentration of VFA's and/or change percentage distribution of the acids. Concentration of rumen short-chain fatty acids is dependent not only on the amount produced but also on the rate of absorption of the acids through the rumen wall. A greater energy need per unit time by the animal could accelerate absorption of VFA's and consequently keep the concentration at a somewhat lower level.

The pH of rumen contents of wild deer seems to be lower (5.40 to 5.63; Short *et al.*, 1966) than that for cattle on hay diet (6.0 to 6.8; Annison and Lewis, 1959). It is generally agreed among rumen nutritionists that a high-fiber low-concentrate diet favors a pH close to neutral. This increases the total numbers of cellulolytic organisms, while a low fiber high-concentrate ration would cause the pH to drop with the corresponding drop in the number of cellulolytics. Experiments of Hungate and his co-workers (Hungate, 1950; Hungate *et al.*, 1952) suggest that some of the fiber-digesting bacteria will not grow and ferment cellulose if the pH drops below 5.5. Lactic acid, the principal causative agent of low pH values in the rumen, is present in the ingesta of deer (1.40-2.46 mg%, Nagy and Ghorban, unpublished). In cows fed alfalfa hay ration Ghorban *et al.*, (1966) found values of lactic acid ranging from 2.5-5.0 mg% of lactate. The concentration of lactic acid in the rumen will depend on time after feeding, type of diet and the physical form of the diet. Total numbers of culturable microorganisms (one to 10 billion per gram of rumen contents) seem to be the same for cattle (Bryant and Burkey, 1953), for roe and red deer (Bruggemann *et al.*, 1967) and for mule deer (Nagy and Tengerdy, 1968). The numbers of cellulolytic organisms, however, seem to differ. Bruggemann *et al.* (1967) found smaller numbers of cellulose digesters in the rumen contents of roe deer than in red deer. We have found lower numbers of cellulose digesters in the rumen contents of wild mule deer than in cattle fed hay or sheep fed hay and concentrates. Digestion trials conducted by Maynard *et al.* (1935) indicated lower crude fiber digestion values for deer than for sheep kept on the same diets.

Short (1963) found that *in vitro* cellulose digestion was frequently less when the rumen fluid of white-tailed deer was used than when the rumen fluid donor was cattle. Our short-term, up to 6 hours, *in vitro* trials with wild deer, cattle and sheep indicated that rumen microbial activity as measured by gas and VFA production is the same for animals on somewhat comparable diets (Nagy *et al.*, 1967). Those short-term trials did not include the digestion of cellulose, showing only that the easily digestible plant materials of alfalfa hay can be utilized by wild deer rumen microorganisms in the same manner as in cattle or sheep.

Hungate *et al.* eloquently discussed the need for smaller ruminants to have a higher fermentation rate in the rumen because the energy requirements of mammals increase as weight decreases. The suni, an antelopelike African Bovid, the smallest ruminant that Hungate investigated, had the smallest rumen compared to total body weight, but showed the greatest rumen fermentation rate in relation to body weight. The rumen contents of suni disclosed green seeds and foliage rather than grass. This increased fermentation rate could come from the larger amounts of easily digestible carbohydrates in the diet of suni. Bruggemann *et al.* (1963) found higher crude protein and lower crude fiber values in the rumen contents of the smaller roe deer than in red deer. The rapid turnover rate of ingesta in smaller ruminants, as suggested by Hungate, could mean less dependence on rumen microbial digestion and more dependence on a monogastric type of digestion. One would then expect the concentration of VFA's in the blood of smaller ruminants to be correspondingly less. Otherwise, if a high turnover rate means also a higher rate of microbial digestion in the rumen, VFA levels of blood in smaller ruminants should be greater. Unfortunately, at least to my knowledge, there is no information available on the VFA levels of blood in deer or other wild ruminants.

High VFA levels in ruminant blood are associated with a low blood sugar level. Young ruminants, in which the rumen is non-functional or just beginning to function, have very low VFA levels and high blood glucose similar to monogastrics. The normal blood glucose concentration in monogastrics is between 78 and 97 mg/100 ml of blood, (Moir, 1965) while that of camel (a pseudo ruminant) 75-99 (McCandless and Dye, 1950), of white-tailed deer 66 to 93 (Maynard *et al.*, 1935) and of cattle 36 to 57. Blood glucose levels are subject to sudden changes due to food intake or fright and this needs further investigation before definite conclusions can be made. Wild ruminants probably have to be anaesthetized to order to obtain valid information.

An additional method which might be used in determining the contribution of rumen microbial fermentation to the total energy balance of deer would be to examine the percentage distribution of higher fatty acids in the tissues of deer. Moir (1965) presented some interesting data on differences in the fatty acid composition in adipose tissue of animals with different dependence on microbial fermentation. We began collecting data on this subject in 1968 in wild mule deer but data collected so far are too limited to warrant any conclusions. There seems to be no doubt, however, that the fat reserves of deer are smaller than that of comparable domestic ruminants. Anderson, *et al.*, (1968) made some comparisons between the carcass fat value of domestic sheep and that of 18 mule deer collected in Colorado between January and August. Although they point out some difficulties in comparisons, the magnitude of differences in carcass fat between 20 lambs (31.6%) and that of 18 deer (5.54%) suggest that deer have significantly less fat in reserve for emergencies, such as prolonged starvation, consequently deer are more dependent on a continuous high energy food supply than e.g., sheep.

The rate of passage of the ingesta through the digestive tract of deer would also be of critical interest to the wild ruminant nutritionist. This subject has been investigated very little in wild ruminants although voluminous data have been collected on their domesticated counterparts.

It is generally agreed that in domestic ruminants increased digestibility of feeds will result in greater energy uptake. Increased digestibility will increase turnover rates of nutrients, as well as fermentation rates, resulting in greater weight gains (Johns *et al.*, 1963). There are several factors which may affect rate of food passage through the digestive tract. Among these are: the amounts of soluble carbohydrates (sugar, starch), the concentration of crude fiber, the physical form of feed (e.g., long vs. pelleted hay) and levels of protein in the diet.

Work on passage rates of ingesta and turnover rates of nutrients coupled with other physiological data could answer some hitherto unanswered questions of deer management. Such questions are: Why do deer which have been feeding on natural browse starve when fed artificial diets, e.g., hay? Which would be the main nutritional constituents, i.e., crude fiber, etc. of a diet that could be fed successfully in emergency situations to deer?

To examine the effects of different crude fiber and crude protein levels on food intake we fed three groups of mule deer (approximately equal in age and weight) three types of hay: good quality alfalfa, poor quality alfalfa and native hay for 21 days. Crude fiber percent was 27.0, 42.0 and 31.1 in the three different hays, while crude protein was 18.0, 16.4 and 4.5 percent, respectively, on a dry weight basis. Food intake differences were obvious. Average daily food intake per group of deer during the trial was 10.3, 5.1 and 4.7 gm. per kg. of body weight for good and poor quality alfalfa and native hay respectively. These intakes resulted in average weight losses of 3.2, 6.8 and 7.9 percent of body weight, respectively for the three hays. Food intake on good quality hay could be increased. When the same good quality hay was fed to animals over an eight week period but the hay available to the animals was increased from 1,000 to 3,000 g food, intake increased from 10.3g to 20.1g per day per kg body weight. Deer evidently selected the leafy parts of hay which was more digestible.

It was evident from this trial that both crude fiber levels and crude protein levels affected food intake. The protein content of the poor quality hay was 16.4 percent, well within the range suggested for deer by Murphy and Coates (1966) and by Ullrey *et al.* (1967). The crude fiber content, however, was very high (42.0%). The high fiber content and correspondingly low soluble carbohydrates probably made this food desirable for deer. Although the crude fiber content (31.1%) was lower in native hay than in poor quality alfalfa, the very low crude protein content (4.5%) was probably objectionable to deer. Deer, of course, have been known for some time to be particular about hay. The experiments of Maynard *et al.* (1935) showed that white-tailed deer will consume good quality alfalfa hay readily and maintain their weight on it, while they will not eat marsh hay in appreciable amounts. Doman and Rasmussen (1944) also pointed out that the quality of hay as well as its physical form greatly influences feed intake of deer.

The physical form of crude fiber will affect dietary intake and dry matter turnover rate (Balch and Campling 1965). Hakonson and Whicker (1967) found no significant differences in elimination curves of orally administered^{137} Cesium when the diet (mainly rice hulls) contained different levels of crude fiber (9.6, 13.7 and 24.1%): Cesium, however, is not considered to be a good marker since it is taken up partially by the animal and not completely excreted. The crude fiber content was not extremely high in Hakonson's experiment and this may have been a significant factor.

To test the effects of different levels of crude fiber on food intake and rate of passage of ingesta through the digestive tract we fed deer three diets containing different levels of crude fiber (7.1, 27.2 and 36.2%). These rations were mainly cottonseed hulls and the protein levels were kept constant at 15 percent. Although cottonseed hulls are hard to digest, the physical form contrasts sharply with long hay. Using the Latin square design, groups of two deer were kept on each diet for one week after a five day pre-trial period. Chromium oxide was used as a marker. In spite of the high amount of crude fiber in one of the diets, food intake was not adversely affected. In fact, the daily food intake was the highest, 22.0g per kg. of body weight, on the high fiber followed by medium fiber (21.5/kg. body weight) and low fiber (9.8g/kg. body weight). Chromium oxide elimination curves showed that the fastest elimination of the marker occurred on high fiber diet (60 hrs), followed by medium fiber (72 hrs) and low fiber (84 hrs). Although numbers of animals were too low and the trial periods too short to make definite conclusions, the results suggests that deer can handle high fiber diets if the physical form of the diet is appropriate and if the diet is adequate in other nutrients. Long-term effects of such diets, of course, should be investigated.

During the foregoing presentation we have tried to point out similarities between deer and other ruminants and, at the same time, we discussed differences which exist between deer and other ruminants as well as some of the areas where our knowledge is inadequate or missing. Deer, although true ruminants, evolved characteristics of their own. While we can make good use of knowledge obtained from domestic ruminants, the more intensive deer management of the future will call for a thorough knowledge of deer physiology and the intelligent application of this knowledge in management practices.

LITERATURE CITED

Anderson, A. E., D. E. Medin and D. P. Ochs.
1698. Densitometric and ether extract estimates of percent carcass fat in mule deer. (Manuscript prepared).

Annison, E. F. and D. Lewis.
1959. Metabolism in the rumen. Methuen and Co. Ltd. London. 184 pp.

Bailey, J. A.
1967 Sampling deer browse for crude protein. J. Wildl. Mgmt. 31(3): 437-442.

Balch, C. C. and R. C. Campling
1965. Rate of passage of digesta through the ruminant digestive tract. *In:* Physiology of digestion in the ruminant. *ed:* R. W. Dougherty. Butterworths, Washington. 48 pp.

Balch, C. C. and S. J. Rowland.
1957. Volatile fatty accids and lactic acid in the rumen of dairy cows receiving a variety of diets. Brit. J. Nutr. 11(3): 288-296.

Bruggemann, J. D. Giesecke und K. Karst
1963. Untersuchungen am Panseneinhalt von Reh und Rotwild. 6th Congr. Int. Union Game Biol. Bournemouth, Engl. 139-144.

Brugemann, J. D. Giesecke und K. Walser-Karst.
1967. Beitrage zur Wild biologie und vergleichender Tierphysiologie. II. Microorganism in pansen von Rothirsch (*Cevus elapus*) und Reh (*Capreolus capreolus*) Zeitscher. fur Tierphys., tierern und Futterm. 23: 143-151.

Bryant, M. P. and L. A. Burkey
1953. Cultural methods and some characteristics of some of the more numerous groups of bacteria in the bovine rumen. J. Dairy Sci. 36: 205-217.

Cowan, R. L.
1968. Paper presented U.S.D.A. Forest Science Range and Wildl. Habitat Eval. Res Worksh. Flagstaff, Ariz. May 20, 1968.

Dietz, D. R., R. H. Udall and L. E. Yeager
1962. Chemical composition and digestibility by mule deer of selected forage species, Cach La Poudr range, Colorado. Colo. Game and Fish Dept. Tech. Bull. 14. 89 pp.

Doman, E. R. and D. I. Rasmussen.
1944. Supplemental winter feeding of mule deer in northern Utah. J. Wldl. Mgmt. 9(4): 317-338.

Hakonson, T. E. and F. W. Whicker
1967. Uptake and elimination of 134 Cesium by mule deer. 2nd Nat. Symp. on Red. Ecol. Paper No. 100-1156-24. Ann Arbor, Mich.

Hungate, R. E.
1950. The anaerobic mesophilic cellulolytic bacteria. Bact. Rev. 14(1): 1-49.

Hungate, R. E., R. W. Dougherty, M. P. Bryant, and R. M. Cello
1592. Microbiological and physiological changes associated with accute indigestion in sheep. The Cornell Vet. 42(4): 432-448.

Hungate, R. E., G. D. Phllips, A. McGregor, D. P. Hungate and H. K. Buechner
1959. Microbial fermentation in certain mammals. Science. 130(3383): 1192-1194.

Ghorban, K. Z., K. L. Knox, and G. M. Ward
1966. Concentration of volatile fatty acids and lactic acid in the rumen as influenced by diet and post feeding time. J. Dairy Sci. 49(12): 1515-1518.

Johns, A. T., M. J. Ulyadt and A. C. Glenday
1963. Pasture type in relation to live-weight gain, carcass composition iodine nutrition and some rumen characteristics of sheep IV. Some rumen characteristics of sheep. J. Agr. Sci. 61: 201-207.

Kleiber, M.
1932. Body size and metabolism. Hilgardia. 6: 315-353.

Maynard, L. A., R. Darrow, G. Bump and J. C. Woodward
1935. Food preferences and requirements of the white-tailed deer in New York State. N. Y. State Cons. Dept. Bul. 1: 1-35.

McCandless, E. L. and J. A. Dye
1950. Physiological changes in intermediary metabolism of various species of ruminants incident to functional development of rumen. Am. J. Physiol. 162: 434-446.

Moir, R. J.
1965. The comparative physiology of ruminant-like animals. *In:* Physiology of digestion in the ruminant *Ed: R. W. Dougherty,* Butterworths, Washington. 480 pp.

Morrison, F. B.
1949. Feeds and feeding. 21st Ed. Morrison Publ. Co., Ithaca, N. Y. 1206 pp.

Murphy, D. A. and J. A. Coates
1966. Effects of dietary protein on deer. Transact. 31st N. Am. Wildl. and Nat. Res. Conf. 129-139.

Nagy, J. G., G. Vidacs and G. M. Ward
1967. Previous diet of deer, cattle and sheep and ability to digest alfalfa hay. J. Wildl. Mgmt. 31(3): 443-447.

Nagy, J. G. and R. P. Tengerdy
1968. Antibacteria laction of Essential oils of *Artemisia* as an ecological factor. II. Antibacterial action of the volatile oils of *Artemisia tridentata* (big sagebrush) on bacteria from the rumen of mule deer. Appl. Microbiol. 16(3): 441-444.

Silver, H., N. F. Colovos and H. H. Hayes
1959. Basal metabolism of white-tailed- deer—a pilot study. J. Wildl. Mgmt. 23(4): 434-438.
Sisson, S. revised by J. D. Grossman
1953. The anatomy of the domestic animals. 4th ed. W. B. Saunders Co. Philadelphia and London. 972 pp.
Short, H. L.
1963. Rumen fermentations and energy relationships in white-tailed deer. J. Wildl. Mgmt. 27(2): 184-195.
Short, H. L., D. E. Medin and A. E. Anderson
1966. Seasonal variations in volatile fatty acids in rumen of mule deer. J. Wildl. Mgmt. 30(3): 446-470.
Thomas, J. W., J. R. Ingalls, M. Yang and B. S. Reddy
1961. Effect of *ad libitum* or equalized feeding of alfalfa hay or silage on rumen contents and its characteristics. (Abstr.) J. Dairy Sci. 44(6): 1203.
Ullrey, D. E. W. G. Youatt, H E. Johnson, L. D. Fay and B. L. Bradley
1967. Protein requirements of white-tailed deer fawns. J. Wildl. Mgmt. 31(4): 679-685.

DISCUSSION

DR. COWAN: I am not sure about the inference Dr. Nagy made about the fact that we might sometime have to start feeding our deer in the wild. But I guess it is a good idea to be looking forward to that possibility.

Perhaps you could tell me, Dr. Nagy, when you gave these deer on the various rations the larger amount were they still able to hold their weight or did they continue to lose weight?

DR. NAGY: The experiments we conducted were with cottonseed hulls. I don't think the time element involved was really sufficient to tell whether they will maintain their weight. We ran a series of trials like this for ten days and couldn't see any decrease in weight. But I am sure if we ran the trials for two or three weeks, this could be possible. So I cannot truly answer the question.

PESTICIDES—NEW FACTS, OLD PROBLEMS: A PANEL

NEW DEVELOPMENTS IN FOREST INSECT PROBLEMS

ARTHUR D. MOORE
Pacific Southwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, Berkeley, California

Water and air pollution and other forms of deterioration in our environment are sources of considerable concern in forestry as in other fields. Efforts to minimize contamination by pesticides fall into two general categories: (1) attempts to find suitable alternatives to conventional insecticides, and (2) attempts to increase the efficiency and selectivity of the chemicals used.

The day is probably not far off when we will use pheromones, insect diseases, hormones, or other agents—instead of conventional insecticides—against some of our forest insect pests. Considerable progress has been made in isolating, identifying, and synthesizing the pheromones that attract bark beetles to their host trees under natural conditions (Wood *et al.*, 1968; Silverstein *et al.*, 1966). Studies are now being conducted to obtain the background information necessary for using pheromones for control (U.S. Forest Serv. Pacific SW. Forest & Range Exp. Sta., 1968a). The use of a virus disease for the control of Douglas-fir tussuck moth appears so close at the Pacific Northwest Station that work on conventional insecticides for this insect have largely been discontinued. Our laboratory studies have shown an insect hormone is effective against the spruce budworm at doses similar to those needed with the most toxic conventional insecticide.

We are studying the possibilities of getting the tree to work for us when it is necessary to get a chemical to an insect protected by plant tissue, e.g., the lodgepole needle miner (U.S. Forest Serv. Pacific SW. Forest & Range Exp. Sta., 1968b). In the not-too-distant future, we may be able to apply complex super molecules that readily penetrate the waxy cuticle of the foliage. From then on they are converted, by plant enzymes, to water-soluble molecules which move with the plant sugars and concentrate at the point of insect feeding activity. Hopefully, the active portion of the molecule will be a selective synthetic hormone or similar compound.

In the meantime, a major effort is being made by the U.S. Forest Service to increase the efficiency and selectivity of treatments with the more conventional-type chemicals.

The initial target in this endeavor at the Pacific Southwest Station continues to be the spruce budworm (U.S. Forest Serv. Pacific SW. Forest & Range Exp. Sta., 1965). To meet the immediate need of a treatment for this insect, it was necessary to turn to chemicals in production or experimental chemicals near the production stage and to the basic application equipment and procedures developed for DDT. Chemicals in or near production are not truly specific for the budworm, as their insecticidal activity was discovered in other insects. However, we believed that a selective treatment could be developed if three conditions were met: (1) if an insecticide could be found that would be more toxic to the budworm than to other organisms; (2) if it could be directed to the target insect with a higher degree of efficiency than to other organisms; and (3) if the parent insecticide and any active metabolites would be broken down in the forest ecosystem—thus, not build up in any plant or animal systems.

A carbamate insecticide, Zectran® (Dow Chemical Company) has shown a higher degree of selectivity for the budworm than any other chemical tested to date (U.S. Forest Serv. Pacific SW. Forest & Range Exp. Sta., 1967). It has a relatively high acute oral toxicity to mammals, but much lower dermal and chronic feeding toxicity—which are the main potential hazards in field use (Kenaga, 1966). Because it is much more toxic than DDT to the budworm, it can be used in much smaller quantities. The parent compound and main active metabolites are readily broken down by sunlight and in plant and animal systems (Abedel-Wahab *et al.*, 1966; Abdel-Wahab and Casida, 1967; Crosby *et al.*, 1965; Oonnithan and Casida, 1966; Oonnithan, 1966).

All studies to date (including studies on fish and wildlife) indicate that this material meets our first and third conditions to a higher degree than the other candidate compounds now available and that it can be used effectively and safely in the field. This then brought us to condition number 2—the task of directing the spray with greater efficiency to the target than to other organisms.

We found that one of the major problems involved in efficiently distributing a pesticide from the air to a forested area is penetration of the canopy. Any vegetation acts as a filtration system, but coniferous forests are especially efficient in filtering out the larger drops of a conventional aerial spray (Maksymiuk, 1963). Earlier work by other workers indicated that drops more than 100 microns in size penetrate vegetation only slightly or not at all. Most forest spraying is carried out with an atomization of 150 microns mass median diameter (Maksymiuk, 1964).[1] Thus, greater than 75 percent of the spray volume is in drop sizes too large to penetrate vegetative filtration

[1]50 percent of the spray volume being in drop sizes larger than 150 microns and 50 percent of the spray volume in drop sizes below 150 microns.

systems, especially those 100 feet in height. We reasoned that in a coniferous forest inhabited by budworm, the most efficient drop sizes might fall considerably below 100 microns. To test this possibility, we made a study to determine which drop sizes were actually getting to the budworm larvae. First, we had to develop a method for studying this variable. We found that very fine fluorescent particles suspended in the spray tended to distribute themselves according to spray volume in any given drop (Himel *et al.*, 1965). Thus, by counting the number of fluorescent particles left by a drop it was possible to obtain the approximate original size of that drop.

More than 1,000 spruce budworm larvae affected by spray in an experimental area were examined to determine the size and number of spray drops impinging on each insect (Himel and Moore, 1967). No evidence was found that a significant number of drops larger than 100 microns reached the target insects. Also, only a small number of droplets between 50 to 100 microns were found, and these on only 7 percent of the larvae. The study clearly indicated that only drops below 50 microns in diameter reached the budworm larvae with any high degree of efficiency. This finding is especially significant when we consider that about 95 percent of the spray applied to forests by conventional methods consists of droplets larger than 50 microns. This spray not only does not reach the target for which it is intended, but it is a major source of environmental contamination.

Next, we asked the U.S. Forest Service Equipment Development and Testing Center at Missoula, Montana, to develop a spray system that would eliminate the undesirable larger drop sizes. A system has now been developed that eliminates all drops above 120 microns in size. Freon is used to give additional breakup of the spray.

By means of aerially released oil smokes (less than 1 micron particle size) and by following fine aerial sprays with Lidar [laser radar equipment developed by the Aerophysics Group at the Stanford Research Institute (Anonymous, 1966)], we found that small airborne droplets reach the tree crowns and the budworm larvae through atmospheric transport and diffusion. Furthermore, diffusion and thermal and physical turbulence near the forest canopy may have been unrecognized allies in past operations.

Observations of the efficiency of different drop sizes pointed our attention to the importance of such bodies as setal hairs on the insect and silken webbing in determining the potential effectiveness of an aerial spray. These bodies are extremely efficient impingement devices for very small droplets.

Studies are also being conducted to determine ways to reduce the potential sting of some conventional type insecticides. For example, addition of an N-acyl substituant to the carbamyl moiety of carbamates usually maintained biological activity on spruce budworm, but decreased the toxicity to mice to the point where a dosage of 1 gram per kilogram produced no visible effect. Thus, it is possible, by acetylation, to lower substantially the acute toxicity of these compounds to mammals without significantly altering their toxicity to spruce budworm.

In addition to the studies on control agents and their application, the Forest Service is emphasizing research on when and where to apply the treatments I have described, and how to integrate them with other applied or natural agents regulating the insect pest population.

In summary, an all-out effort is being made to substitute finesse for brute force in forest insect control.

LITERATURE CITED

Abdel-Wahab, A. M., R.J. Kuhr, and J.E. Casida
1966. Fate of C-14 carbonyl-labeled aryl methylcarbamate insecticide chemicals in and on bean plants. J. Agr. Food Chem. 14:290-298.

————, and J. E. Casida
1967. Photooxidation of two 4-dimethylaminoaryl methylcarbamate insecticides (Zectran and Matacil) on bean foliage and of alkylaminophenyl methylcarbamates of silica gel G chromatoplates. J. Agr. Food Chem. 15: 479-487.

Anonymous
1966. The lidar assists in forest pest research. J. Stanford Res. Inst. 11(1966): 8-9, illus.

Crosby, D. G., E. Leitis, and W. L. Winterlin
1965. Photo-decomposition of carbamate insecticides. J. Agr. Food Chem. 13: 204-207.

Himel, C. M., and A. D. Moore
1967. Spruce budworm mortality as a function of aerial spray droplet size. Science 156 (3779): 1250-1251.

————, Leland Vaughn, Raymond P. Miskus, and Arthur D. Moore
1965. A new method for spray deposit assessment. U.S. Forest Serv., Pacific SW. Forest & Range Exp. Sta. Res. Note PSW-87, 10 p., illus.

Kenaga, E. E.
1966. Commercial and experimental organic insecticides. Bull. Entomol. Soc. Amer. 12(2): 161-217.

Maksymiuk, Bohdan
1963. Screening effect of the nearest tree on aerial spray deposits recovered at ground level. J. Forest. 61(2): 143-144.

————
1964. The drop size spectra method for estimating the mass median diameter of aerial sprays. U.S. Forest Serv. Res. Paper WO-1, U.S. Dep. Agr., Washington, D.C. 11 p., illus.

Miskus. R. P.. Melvin Look. T. L. Andrews, and R. L. Lyon
1968. Biological activity as an effect of structural changes in aryl N-methylcarbamates. J. Agr. Food Chem. 16(4): 605-607.

Oonnithan, E. S.
1966. Metabolites of methyl- and dimethylcarbamate insecticide chemicals as formed systems. (Ph.D. thesis, Univ. Calif., Berkeley.)

————, and J. E. Casida
1966. Metabolies of methyl- and dimethylcarbamate insecticide chemicals as formed by rat liver microsomes. Bull. Environ. Contamination Toxicol. 1(2): 59-69.

Pieper, G. R., and R. P. Miskus
1967. Determination of Zectran residues in aerial forest spraying. J. Agr- Food Chem. 15(5): 915-916.

Silverstein, R.M., J. Otto Rodin, and David L. Wood
1966. Sex attractants in frass produced by male *Ips confusus* in Ponderosa pine. Science 154(3748): 509-510.

U.S. Forest Serv. Pacific Southwest Forest and Range Experiment Station.
1965. Evaluation of chemicals for control of forest insects. Berkeley, Calif. 8 p., illus.

————.
1967. Zectran—for control of spruce budworm. Berkeley, Calif. 6 p., illus.

————.

1968a. Bark beetles "turn on." In, What's New in Research. Berkeley, Calif. p. 1-3.

———. 1968a. Designing a super molecule—a symplastic systemic insecticide. In, What's New in Research. Berkeley, Calif. p. 1-4, illus.

———. 1968c. New spray system effective. In What's New in Research. Berkeley, Calif. p. 6.

Wood, David L., Lloyd E. Browne, William D. Bedard, Paul E. Tilden, Robert M. Silverstein, and J. Otto Rodin.
1968. Response of *Ips confusus* to synthetic sex pheromones in nature. Science 159 (3821): 1373-1374.

COHO SALMON MORTALITY AND DDT IN LAKE MICHIGAN[1]

HOWARD E. JOHNSON AND CHARLES PECOR[2]
Fisheries and Wildlife Department, Michigan State University, East Lansing, Michigan

INTRODUCTION

The hazards of pesticides to fish and other aquatic life have been widely discussed. We are familiar with the dramatic losses of fishery resources which followed broad applications of DDT in our northern and western forests (Cope, 1961; Elson, 1967; Ide, 1967); the massive fish kills in the Mississippi River in 1963 (Mount and Putnicki, 1966); and the classic example of pesticide accumulation through the food chain in Clear Lake, California (Hunt and Bischoff, 1966). Similar losses of less dramatic proportions have been recorded in many areas (Johnson, 1968).

In recent years considerable emphasis has been placed on the finding of DDT and other organochlorine pesticide residues in the tissues of both marine and freshwater fish. Monitoring studies have revealed the wide distribution of these compounds in aquatic systems (Lyman *et al.*, 1968; Kleinert *et al.*, 1968) but, in general, biologists have failed to determine the biological significance of pesticide residues accumulated in fish tissues.

A problem of immediate concern is the potential effect of pesticide residues on reproduction in fishes. Several investigators (Burdick *et al.,* 1964; Allison *et al.,* 1964; *Cuerrier* et al., 1967; Macek, 1968; and Johnson, 1967) have found evidence that organochlorine pesticides accumulated in the eggs of apparently healthy adult fish may be lethal to the hatching fry during the last stages of development. That this phenomenon has been observed in both hatchery and field situations, with several different fish species and with more than one organochlorine compound is cause for serious concern. It is this

[1]The studies reported herein were supported in part by: The William R. Angell Foundation in cooperation with the Sport Fishery Research Foundation, The Michigan Department of Natural Resources and Michigan State University Agriculture Experiment Station, Article No. 4658.
[2]Supported by F.W.P.C.A. Training Grant 5T1-WP-109.

problem which stimulated our present study of pesticides in Lake Michigan salmonids.

Major alterations of the fish stocks in the Great Lakes have occurred since 1940 (Smith, 1968). A total collapse of the Lake Michigan fishery followed a series of catastrophic events, which included overexploitation, lamprey predation, and the rapid increase in abundance of the alewife (*Alosa pseudoharengus*). Vigorous efforts are now under way to reestablish population stability of Great Lakes fish stocks and to enhance the management of Great Lakes fisheries for maximum recreational and commercial value. Lake trout stocking began in 1965 and has been followed by the introduction of coho salmon (*Oncorhynchus kisutch*) in 1966 and chinook salmon (*O. tshawytscha*) in 1967.

Lake Michigan, with a drainage basin of nearly 45,000 square miles, is subject to repeated contamination by pesticides from large areas of intensive agriculture and densely populated urban centers throughout much of its watershed. Indeed Hickey *et al.* (1966), in a study of a Lake Michigan ecosystem, found DDT distributed in all trophic levels and concluded that pesticide pollution in Lake Michigan was probably widespread. Carr and Reinert (1968) in a three-year monitoring study of Great Lakes fishes found DDT in all species with concentrations in Lake Michigan fishes two to four times higher than in those from the other lakes.

Several years of unexplained high losses of steelhead trout fry in Michigan hatcheries first suggested that present levels of pesticides in Lake Michigan may interfere with fish reproduction. The losses characteristically occurred during the last stages of yolk absorption when the fry first began to feed. Although hatchery biologists examined for disease and adverse water quality conditions, a satisfactory explanation of the losses has not been found.

Coho Salmon Fry Mortality.

In 1967, losses of a very similar nature occurred in the progeny of the first mature coho salmon from Lake Michigan. The Michigan Department of Natural Resources collected approximately eight million eggs from coho salmon entering the Platte River and Bear Creek from Lake Michigan. Approximately 1.1 million eggs were distributed to four other states and the Province of Ontario and the remaining 7.9 million eggs were distributed among five Michigan hatcheries. Records from each state hatchery indicate mortalities of the hatching fry increased abruptly during final yolk-sac absorption and early feeding periods. Similar losses were reported by other states which received eggs from Michigan. Total losses in Michigan during this period alone accounted for approximately 680,000 fry or 11 percent of the original egg number. The mortality began in the fourth or fifth week after hatching, increased to peak numbers in the sixth or seventh week, and had generally ended by the eighth week. As the mortality was restricted to a particular development stage of the fry, the syndrome appeared earlier and in greater proportions in hatcheries with warmer water temperatures.

The mortality was characterized by loss of equilibrium, erratic swimming at the surface, and prolonged convulsions in reponse to sudden disturbance. The affected fry gradually weakened, sank to the tank bottom and died within a few days. Many fry turned dark even before losing equilibrium, but color change was not a uniform characteristic of all affected individuals. The stomachs of affected fry uually contained some yolk but no food. No external or internal lesions were observed, with the exception of a few which showed degeneration of the kidney and liver tissues.

Losses of coho salmon fry from eggs received from Oregon and from eggs collected in tributaries of Lake Superior were negligible during the same period. No evidence of the above symptoms were reported in these groups even though they were reared in the same hatcheries where high losses of Lake Michigan groups occurred.

Samples of affected and non-affected fry were examined by pathologists at the U.S. Fish and Wildlife Service, Eastern Fish Disease Laboratory in Leetown, West Virginia. Cell cultures were innoculated with homogenates of moribund fry; specimens from each group were prepared for histopathological examination, and infectivity tests with healthy fish were conducted. No evidence of an infectious disease was found in the samples examined (Dr. Kenneth Wolf, personal communication). Additional tests by fish pathologists of the Michigan Department of Natural Resources failed to find any specific pathogen associated with the affected fry.

The present study was initiated in 1967 to identify and quantify the concentrations of pesticides in eggs of Lake Michigan salmonids and to determine the effect of these compounds upon the development and survival of the hatching fry. As a result of our 1967 study and the relatively high mortalities of coho salmon from Lake Michigan we have expanded our investigation during 1968.

The purpose of this paper is to discuss our preliminary findings as they relate to the mortalities of coho salmon fry from Lake Michigan and the significance of pesticide residues in Lake Michigan fishes.

METHODS AND MATERIALS

Coho salmon used for pesticide analysis were obtained from several locations during 1967, including mature spawning adults taken at weir sites on tributary streams, and eggs and fry from several hatcheries in Michigan. Coho salmon eggs from Lake Superior and Oregon were included for comparative purposes.

To compare the concentration of pesticides in coho salmon eggs with survivial of the hatching fry, fertilized eggs from 20 individual females from Lake Michigan, two from Lake Superior and two from Oregon were reared in the laboratory. A subsample of eggs from each female was taken for pesticide analysis at the time of fertilization and the remaining eggs were placed in individual compartments of a 16-tray salmon egg incubator which received carbon filtered water held at 10°C. Two weeks after hatching, subsamples of 150 fry selected at random from each sample group were transferred to 12-liter glass tanks, which received carbon-filtered water at temperatures which ranged from 13°C to 16.5°C. Mortalities of fry in each tank were recorded daily for a period of eight weeks after hatching. The fry were fed Oregon-Moist diet three times daily. DDT residues in samples of the diet were less than 0.01 ppm.

Samples for pesticide analysis were immediately frozen and stored at —10°C. Egg samples were blotted dry and 2- to 5-gram quantities were ground with anhydrous sodium sulfate, extracted three times with a 6:94 ethyl ether: petroleum ether mixture, and cleaned-up on activated florisil (Mills *et al.*, 1963). The eluted fractions were concentrated on a rotary evaporator and quantitatively transferred to glass-stoppered samples tubes.

Analysis was completed by gas chromatography using a Micro-tek 220 instrument equipped with a ¼-in-by-6 foot glass column packed with 3 percent SE-30 on 60-80 mesh Gas Chrom-Q. The column temperature was 180°C with a carrier gas flow of 70 ml/min nitrogen. Sample identity was confirmed by thin-layer chromatography, injection on a second column (10 percent QF-1 on 60-80 mesh Gas Chrom-Q) and by exchange with two other laboratories.

RESULTS AND DISCUSSION

Residue Concentrations.

DDT (including p,p'-DDT, p,p'-DDE and DDD) were identified in all samples of coho salmon eggs from Lake Michigan, Lake Superior, and Oregon. In the majority of samples taken during 1967, only p,p'-DDT values were quantified. Orthopara,-DDT and o,p'-DDE peaks were tentatively identified in the majority of chromatograms from Lake Michigan and Lake Superior samples, but the concentrations were generally below levels of detectability.

The mean values of DDT compounds in Lake Michigan coho salmon eggs range three to five times higher than in those from Lake Superior and approximately 60 times higher than in Oregon samples (Table 1).

The DDT concentrations in coho salmon eggs from Lake Michigan are comparable to levels which caused mortalities in brook trout fry (Macek, 1968). If total residues of DDT compounds are considered, levels found in the coho salmon eggs are higher.

Burdick *et al.* (1964) reported mortality of lake trout fry occurred when DDT residues in the eggs were 2.9 ppm or higher as determined by the Schecter-Haller method; a procedure which includes both DDT and DDD as a single value. The combined mean values of DDT and DDD in Lake Michigan coho salmon eggs approach this critical concentration.

Fry Mortality.

DDT concentrations (p,p'-DDT in wet weight of the eggs) in eggs held in the laboratory ranged from 1.09 to 2.76 ppm in the Lake Michigan samples; 0.55 and 0.66 ppm in the Lake Superior samples and 0.01 ppm in the Oregon group.

Mortalities increased rapidly in all Lake Michigan fry groups during the fourth and fifth week after hatching—a period when the fry were first beginning to feed. Cumulative losses through the eighth week after hatching ranged from 15 to 73 percent in the individual Lake Michigan rearing groups. The mortality syndrome was characterized by symptoms identical to those observed in coho fry which died in the Michigan hatcheries. In addition, we also observed that many fry had excess gas in their gut and swim bladder while a few had opaque or clouded eye lenses.

Losses of Oregon and Lake Superior fry groups ranged from less than one percent to five percent during the same eight-week period. No evidence of the mortality syndrome was observed in these groups.

TABLE 1. DDT RESIDUES IN COHO SALMON EGGS IN PARTS PER MILLION WET WEIGHT.[1]

			Residue Concentration ($\bar{x}$ ± SE)			
Year	Location	n	DDT	DDD	DDE	Total[3]
	Lake Michigan					
1967	Platte River	10	1.77 ± 0.16	—	—	—
	Bear Creek	10	1.71 ± 0.14	—	—	—
	Thompson Creek	25	1.94 ± 0.13	0.58 ± 0.03	4.74 ± 0.26	7.27 ± 0.36
1968	Little Manistee River	12	1.64 ± 0.15	0.44 ± 0.03	3.79 ± 0.41	5.86 ± 0.47
	Bear Creek	10	1.76 ± 0.11	0.31 ± 0.02	4.60 ± 0.28	6.66 ± 0.40
	Lake Superior					
1967	Big Huron River	6	0.27 ± 0.12	—	—	—
1968	Cherry Creek	10	0.28 ± 0.10	0.07 ± .04	1.17 ± 0.33	1.16 ± 0.48
	Oregon (State)[2]					
1967		1	0.01	—	—	—
1968		1	0.02	Tr (< 0.01)	0.06	0.09

[1] Only DDT values were determined for 1967 samples.
[2] Oregon sample was composite of eggs from many females. Results indicate mean value of three replicate samples in each year.
[3] Total is average of DDT, DDD, and DDE values.

Higher losses of the fry were generally associated with higher levels of DDT in the eggs but considerable variation was observed between individual rearing groups. Variation in tolerance to DDT between individual fry or between female groups is not unexpected. Our comparisons were related only to DDT concentrations in the eggs but Macek (1968) has suggested DDT may affect the sperm as well. Thus effects on the male parent may contribute to variability between individual sample groups.

As the concentrations of DDT in Lake Michigan coho salmon eggs are within a relatively narrow range, a relatively large sample size would be required to determine a critical concentration below which no mortality would be expected.

In six paired samples of affected and non-affected fry (ten fry each) from individual females we consistently found higher concentrations of DDT in the affected group (mean equals 1.1 ppm) than in the non-affected groups (mean equal 0.5 ppm). We examined this further by analyzing 15 samples each of affected and non-affected fry (50 fry per sample) from the Wolf Lake Hatchery during the peak period of fry mortality. Significantly higher concentrations ($p<0.05$) of DDT and DDE were found in the affected than in the non-affected fry. These data are perhaps more meaningful because they represent samples taken from raceways containing several thousand fry from many females. The non-affected fry were generally somewhat larger and this factor may account for part of the difference in the observed DDT-DDE concentrations. However, these data clearly indicate that, at the time of mortality, affected fry had higher concentrations of DDT per unit body weight (both on wet weight and lipid weight basis) than non-affected fry.

DDT in Gut Tissues.

At the time of the mortality, little or no external evidence of yolk sac was visible in the fry but yolk and lipid material was still evident within the gut. The concentrations of DDT in the gut were determined by analysis of six samples (ten fry each) of coho salmon fry taken from the laboratory rearing groups at the initiation of the mortality. Each fry was eviscerated and the composite of gut tissue for each sample analyzed separate from the composite of body tissues. The gut samples included some viscera but the bulk of the material was the remaining yolk. Approximately 6 to 12 times higher concentrations of p,p'-DDT were found in the gut than in the remainder of the fry (Table 2).

The glyceride fats, which form conspicuous globules within salmon-

TABLE 2. P, P'-DDT CONCENTRATIONS (PPM WET WEIGHT) IN THE GUT AND BODY OF COHO SALMON FRY SAMPLED DURING THE INITIAL STAGES OF THE MORTALITY SYNDROME. (EACH SAMPLE IS A COMPOSITE FROM TEN FRY).

Sample No.	Gut	Body
1	3.145	0.511
2	2.083	0.262
3	1.716	0.325
4	1.933	0.289
5	2.101	0.246

id eggs, are the last fractions of the yolk to be metabolized by the developing fry (Smith, 1957; Hayes and Ross, 1937). DDT is highly lipid soluble; therefore, it is not surprising that high concentrations would be retained in the gut until the glyceride lipids were metabolized. As DDT would be absorbed across the gut when the lipids were metabolized, it appears reasonable that toxic levels could enter the circulatory system of the fry during this stage of development. This phenomenon would explain the abrupt appearance of mortality just prior to initial feeding stages.

SUMMARY

Although dramatic losses of important fishery resources have been attributed to pesticides, the biological significance of pesticide residues accumulated in fish tissue is poorly understood. A problem of immediate concern is the potential effect of organochlorine pesticides on reproduction in fishes.

Preliminary investigations were initiated in 1967 to identify and quantity pesticide residues in coho salmon eggs in Lake Michigan and to determine their effects on the hatching fry.

DDT concentrations in Lake Michigan coho salmon eggs were three to five times higher than in those from Lake Superior and approximately 60 times higher than in eggs from Oregon. A mortality syndrome, characterized by an abrupt appearance of symptoms during the last stage of yolk sac absorption, was observed in all groups from Lake Michigan. No evidence of the symptoms was observed in Lake Superior and Oregon groups.

Higher residues in the eggs of Lake Michigan salmon were, in general, associated with higher mortalities of the fry. Significantly higher concentrations of DDT were found in affected fry than in non-affected fry from the same female.

DDT concentrations in the last fractions of yolk present in the gut when symtoms first appeared were 6 to 12 times higher than in the body tissues. The absorption of relatively high concentrations of DDT from the gut is suggested as an explanation for the mortality of the coho salmon fry.

ACKNOWLEDGMENTS

Our appreciation is extended to the Michigan Department of Natural Resources personnel for information from hatchery records and assistance in collection of samples. The assistance of Dr. M. Zabik, Department of Entomology and Mr. J. Hamelink, Department of Fisheries and Wildlife, Michigan State University, and Dr. R. Reinert, U.S. Bureau of Commercial Fisheries, Ann Arbor, Michigan, is gratefully acknowledged.

LITERATURE CITED

Allison, D., B. J. Kallman, O. B. Cope, and C. C. Van Valin.
1964. Some chronic effects of DDT on cutthroat trout. U. S. Bureau Sport Fish. Wildlife Res. Rept. No. 64. 30 p.

Burdick, G. E., E. J. Harris, H. J. Dean, T. M. Walker, J. Skea, and D. Colby.
1964. The accumulation of DDT in lake trout and the effect on reproduction. Trans. Am. Fish. Soc., 93(2): 127-136.

Carr, J. F. and R. E. Reinert.
1968. DDT and dieldrin levels in Great Lakes fish. Special Report No. 3, Abstracts Eleventh Conference on Great Lakes Research, Milwaukee, Wisconsin, Apr. 18-20, 1968.

Cope, O. B.
1961. Effects of DDT spraying for spruce budworm on fish in the Yellowstone River system. Trans. Am. Fish. Soc. 90(3): 239-251.

Cuerrier, J. P., J. A. Keith, and E. Stone
1967. Problems with DDT in fish culture operations. Le Naturaliste Canadien, Vol. 94: 315-320.

Elson, P. F.
1967. Effects on wild young salmon of spraying DDT over New Brunswick forests. J. Fish. Res. Bd. Canada, 24(4): 731-767.

Hayes, F. R. and D. M. Ross.
1937. A quantitative study of the total fat content of developing salmon eggs. Proc. Royal Soc. London B, 121: 358-375.

Hickey, J. J., J. A. Keith and F. B. Coon.
1966. An exploration of pesticides in a Lake Michigan ecosystem. J. Appl. Ecol., 3 (Suppl.): 141-154.

Hunt, E. G. and A. I. Bischoff.
1960. Inimical effects on wildlife of periodic DDD applications to Clear Lake. Calif. Fish Game 46: 91-106.

Ide, F. P.
1967. Effects of forest spraying with DDT on aquatic insects of salmon streams in New Brunswick. J. Fish. Bd. Canada, (24)4: 769-805.

Johnson, H. E.
1967. Effects of endrin on reproduction in a freshwater fish (*Oryzias latipes*). Ph.D. thesis, University of Washington, Seattle, Washington. 149 p.

Johnson, D. W.
1968. Pesticides and fishes—A review of selected literature. Trans. Am. Fish. Soc., (97)4: 398-424.

Kleinert, S. J., P. E. Degurse, and T. L. Wirth.
1968. Occurrence and significance of DDT and dieldrin residues in Wisconsin fish. Wisconsin Department of Natural Resources Technical Bulletin No. 41. 43 p.

Lyman, L. D., W. A. Tompkins, and J. A. McCann.
1968. Massachusetts pesticide monitoring study. Pesticides Monitoring Journal, 2(3): 109-122.

Macek, K. J.
1968. Reproduction in brook trout (*Salvelinus fontinalis*) fed sublethal concentrations of DDT. J. Fish. Res. Bd. Canada, 25(9): 1787-1796.

Mills, P. A., J. H. Onley, and R. A. Gaither.
1963. Rapid method for chlorinated pesticide residues in non-fatty foods. J. Assoc. Off. Agr. Chem., 46: 186-191.

Mount, D. I., and G. J. Putnicki.
1966. Summary report of the 1963 Mississippi fish kill. Thirty-first N. Amer. Wildl. Nat. Res. Conf. Trans. p. 177-184.

Smith, S.
1957. Early development and hatching. *In* Brown, M. E., ed. The physiology of fishes. Vol. 1. pp. 323-360. Academic Press, New York, New York.

Smith, S. H.
1968. Species succession and fishery exploitation in the Great Lakes. J. Fish. Res. Bd. Canada, 25(4): 667-693.

CHEMICAL INDUSTRY EFFORTS IN SOLVING PESTICIDE-WILDLIFE AND ENVIRONMENTAL PROBLEMS

EUGENE E. KENAGA
Agricultural Products, The Dow Chemical Company, Midland, Michigan

Today we are discussing the attitudes of some of the various vocational groups of people involved in the use of pesticides. These groups are found in the areas of agriculture, natural resources, public health and also include the pesticide manufacturers, university and United States Department of Agriculture (USDA) personnel engaged in discovering, evaluating, developing and recommending pesticides. It is my belief that, aside from attitudes based on occupational responsibilities, no major differences exist in opinions of the above groups about the desirability of using pesticides wisely to protect our natural resources, to produce a bountiful food supply, and to protect human health, with a minimum unfavorable effect on wildlife and its environment.

Despite the fact that there are hundreds of pesticidal compounds and thousands of formulations, little public attention is given to any but DDT and a group of polychlorinated hydrocarbon insecticides which comprise only about 15 percent of the commercial and experimental insecticides (Kenaga, 1966). These compounds are the subject of attention because of their persistent, toxic nature and their widespread use and occurrence in the world. Such compounds are among the older organic insecticides and were introduced at a time when subtle environmental effects were poorly understood and analytical methods were not sensitive enough to detect minute but damaging amounts of these chemicals. During the past year the USDA has reviewed and cancelled the registration and use of a number of pesticide compounds in "grandfather category" because of lack of knowledge of metabolites, environmental effects, and sensitive analytical techniques, as well as lower effectiveness compared to newer pesticides and for other reasons. Now old pesticides must meet the same critical review as new ones. It should be reassuring and of some interest to know what requirements are necessary for registration of a pesticide at the present time.

It is the function and responsibility of the USDA under the Federal Insecticide, Fungicide and Rodenticide Act and amendments, plus the Meat and Poultry Inspection Act, to regulate the use of economic poisons such as insecticides, fungicides, herbicides, etc., shipped in interstate commerce. Registration of each agent and formulation(s) thereof is required by the USDA, and labels must include the name of the product, identity of the active ingredient(s), name and address of the manufacturer, net contents, warning and caution statements, registration number and proven use directions. Such labels are reviewed by the U.S. Department of the Interior (Fish and Wildlife Service) for use patterns which may have an impact on fish or wildlife and by the U.S. Public Health Service from the standpoint of human health and safety before being granted registration by the USDA. Many state departments of agriculture have similar registration functions although most follow the lead of the USDA.

When the use of a pesticide is likely to result in a residue on a food crop then a tolerance must be established by the U.S. Food and Drug Administration. The residue tolerance level required by good agricultural practice is approved by FDA only after a review of comprehensive toxicity data shows it to be safe for humans.

FDA requirements for establishment of tolerances include identity of the chemical (including impurities and metabolites), and formulation; extensive information on toxicology; residue analytical methodology (usually sensitive to 0.1 ppm or less) for the compound and frequently its metabolites; persistence and measurement of amounts of residues resulting from application; and even methods for removing residues. The chemical industry believes that this information is desirable and useful.

When a pesticide is finally registered by the USDA in the year 1969, the safety to man and his environment has been carefully investigated, weighed, and assured beyond any reasonable doubt, when it is used according to its labeling. Industry, most certainly, does not condone misuse of pesticides and supports such labeling. The increasing cost of registration is causing a decrease in the number of compounds developed by industry and available to farmers *et al.*, to combat pests, particularly those for specific pesticidal uses or for control of pests in small crop acreages or those crops with marginal profits. In the future, who will support these people and help them with their pesticidal problems?

The pesticide industry is a large and fairly stable business. Most of the companies are in it to stay. This means we must please our customers as well as cooperators, such as university, state and federal personnel engaged in research and extension. Also, regulatory agencies involved in pesticide uses must be satisfied, scientifically and morally, as to product identity and quality before giving approval related to information in their area of competence. Industrial people who do not meet the same criteria soon fall into disfavor and consequently wield little further influence. Industry cannot afford irresponsible attitudes by employees toward cooperators, customers, and the general public. Most industrial scientists have professional status equal to those engaged in university or governmental endeavors. Most are proud of this and wish to maintain such a reputation for intellectual and scientific honesty.

The primary reason for the chemical industry being in the pesticide business is to produce products at a profit (as for all businesses). If there is no profit we cannot stay in business unless subsidized by government or other agencies or by other more profitable products. Neither of the latter situations would be likely to last for very long.

Profit is the amount of sales money left after subtracting the cost of doing business. The cost of doing pesticide business includes among other things:

Basic research to uncover potential leads
Screening thousands of chemicals to obtain a few that show promise
In depth toxicological studies
Greenhouse and field trials
Formulation expertise
Registration of product
Manufacturing (chemical costs, buildings, equipment, raw materials supply, technical know-how, wages, fringe benefits)
Advertising (literature, radio, TV)
Distribution (traffic, packaging)
Sales and service
Ensuring safety to personnel manufacturing and applying pesticides and the consumer
Determining environmental effects (soil, water, air, wildlife)
Developing uses (before and concurrent with sales programs)
Researching new uses
Patents (and protection from competition in early stages of development so others cannot make free competitive use of the research and development investment)
Liability and insurance
Taxes (which among other things help to finance many university and government projects which include industry regulations)

Built into the cost of doing business is the fact that satisfied employees are important and their safety and health while on the job are our responsibility. Needless to say, customers must be satisfied and the general public welfare must be considered. Industrial people are understandably indignant when accused of "trying to make a fast buck at any cost" or of having no social or scientific conscience. We believe that the profit motive is vital and is no more prejudicidal to actions and judgments as responsible citizens than the motives influencing people in educational, governmental or other activities.

The chemical industry has always looked for compounds which are specifically toxic to target organisms. Many are presently sold where the market will bear the cost of a highly priced-low volume toxicant. Because of limited specific uses, there is often little or no hazard to humans and non-target organisms. Some systemic compounds such as Dow's RUELENE® and KORLAN® insecticides are even applied directly (internally or externally) to cattle to kill serious parasitic insects and worms. These uses are safe to the cattle and the small amount of residues in edible animal products are safe for human consumption.

In general agricultural practice, the farmer is faced with control of major insect pests from several orders of insects, usually at least 3, which may include 6-8 species. Thus, if each species were to require a different specific chemical, a farmer might have to use several compounds, each of which could cost more than a single broader spectrum compound. As a compromise in the past few years the trend has been toward broad-spectrum and short or medium persistence insecticides. Such insecticides control the spectrum of insects on a given crop with the least possible side effects to insect parasites, other beneficial insects, and to wildlife.

During the past ten years of the pesticide-wildlife furor, the chemical industry has sought the counsel of natural resource people in government and university positions. Simple laboratory tests isolating a few parameters of the environmental variables were offered and are still used as valuable indicator tools. It became apparent that many environmental factors were not being accounted for in such tests and that compounds often acted differently in field tests than in the laboratory. Because of the possible permutations relating to environmental variables, statistically sound tests based on natural field conditions are almost impossible to come by. To date neither the Fish and Wildlife Service nor the USDA have been able to establish protocols for such tests. This only emphasizes the difficulty of obtaining satisfactory meaningful tests. Industry has sought and received help from the Fish and Wildlife Service and other natural resource groups in monitoring the field effects of developmental pesticides prior to registration. This involves much work including sampling and analysis of soil, water, and air, as well as, animal and plant residue work, animal population studies, etc. Whole teams of scientists of different disciplines including naturalists, chemists, biologists, applicators, regulatory officials and toxicologists work together, using the most modern tools to obtain the complicated overall picture. A chemical company such as The Dow Chemical Company, has its own industrial and environmental toxicologists who are constantly innovating methods to properly evaluate the toxicology of specific compounds.

In conclusion, it is my belief that the pesticide industry will continue to try to fulfill its major objectives (1) to make a profit, (2) to give people profitable employment, (3) to assure the world of useful chemical tools for producing plant and animal foods and fibers and for protecting stored products from infection and infestation, and (4) to protect man from disease and toxic pesticidal effects. Finally, the fifth objective, which has attained a top ranking in recent years, is to make sure that pesticides do not cause uncalculated, unalterable injury to the earth's wild creatures or to their environment. It must be understood by now that these objectives are not easy to achieve nor inexpensively obtained. Industry is willing to do what the public will demand *and* pay for.

LITERATURE CITED

Kenaga, E. E.
1966. Commercial and experimental organic insecticides (1966 Revision) Bull. Ento. Soc. Amer. 12(2): 161-217.

PANEL DISCUSSION

DR. COWAN: You have just heard three very fine papers reporting research designed to find more specific insecticides and to improve the techniques for reaching the target animals. The second paper shows what can happen when the target animal isn't the only one that is hit, and the third gives a thoughtful and complete statement of Industry's position in this matter.

I would like at this time to open the Panel papers for discussion.

MR. J. W. BECKMAN (New York State Legislator): Recent inspection of one of the hatcheries indicated that some of the coho fry from Lake Michigan were still having a high mortality after seven, eight, and nine weeks. Would you comment on this? The mortalities were higher than those in Oregon and other places.

DR. JOHNSON: Are you referring to mortality in New York hatcheries?

MR. BECKMAN: Yes.

DR. JOHNSON: I would hesitate to comment, since I haven't seen that situation. We stopped our follow-up on mortalities after the ninth week, during our 1968 studies. We found, at water temperatures at which we were operating, that if the mortality is going to occur, it would have occurred by that time. Generally, at the time that we can conclude these studies, there are still fish dying.

Now, if the mortality is due to DDT being absorbed from the lipide material, then I suspect you would see this spread out in eggs which are not from an individual female. In other words, you have got eggs that were taken over a period of time; the development rate is accordingly distributed.

When we are dealing with individual female sample groups, we see the mortality generally limited to this nine-week period.

DR. KENNETH DIEM (University of Wyoming): I address this question to Mr. Kenaga.

The chemical industry has taken a rather unique position. While your talk puts one position forward, it is in direct opposition to a position stated in what I assume is your official magazine called *Farm Chemicals*. In a not-too-long-ago article, there was a prognostication by the writer in this magazine that the outlook was for greater profits and more problems with those people who were seeking consumer protection.

It seemed rather strange that on one hand an industry could look for more money and then decry the fact that the consumer was seeking protection. It seems to me that it is appropriate to ask a question of industry as well as our legislators in this frame. Early in this century, we had a publication by the American Medical Association about patent medicines.

I would ask you, sir, why in the case of medicine the burden of proof that something is dangerous to man is on the industry that makes it. The general tenor of the papers given this afternoon seem to imply that we have to prove industry is contaminating the environment, when industry, it seems to me, should be able to prove that it is not before it can market a product.

MR. KENAGA: I knew I wouldn't have trouble getting into hot water.

I am not familiar with the *Farm Chemical Magazine* editorial policy. I am sure it is not an organ of the chemical industry.

I think that farmers are worried about a possible threat to their tools for use in agriculture. All of us have defensive mechanisms about our own livelihood, so it is understandable that extremists or certain leaders take these defensive positions in public. Privately, you will find most people, except the extremists, will agree that there are at least two sides to each question and I am sure that all of you here realize that.

I was asked why industry isn't forced to prove the safety of the materials that are put out, implying that the safety of medical materials are approved before they are put out.

I don't believe that medical people will say that they have proven these things are safe beyond doubt before they are put out. They will say that they have performed all reasonable test methods and all of the protocol that registration officials say are sufficient to prove them safe. They will not call a product absolutely safe until it has been on the market for a number of years.

In the agricultural area, I would say that in former times, we did not have as many safety precautions as we have now. I am sure you will agree, after listening to the number of items that I mentioned, that it is very rugged to get through the whole mill of requirements.

The new materials certainly have more safeguards put into them than into DDT in regard to breakdown, metabolites, and so on. I am continually amazed to learn how little has been done about some of the metabolites of DDT.

So I think you are looking retroactively. We are asking for anybody's help we can get to offset the effects of chemicals on environment. And I know from talking to you that you have ideas of how it should be done. Most people say we shouldn't have to put up with chemicals in the environment. But I am sure that there are certain types of chemicals that are on their way out.

DR. DIEM (Wyoming): If I could just make one more comment. This is, as far as I know, the most official organ for the chemical industry—*Farm Chemical Magazine*—is the spokesman for the fertilizer, insecticide, the chemical industry.

In it, the author of this article stated that they can expect nothing but trouble because the ARS has been pointedly singled out as overlooking 13 years of chemical pesticide violation without bringing them to the attention of the proper authorities.

At the same time, the editor of this *Farm Chemical Journal* stated that the so-called hassle over pesticides was a tempest in the teapot.

This bothers most of us, because I think we, like you, share the hope that we can continue a useful dialogue. But I would point out that when a journal of such wide circulation comes out as a spokesman for the chemical industry, this does not lend to this type of a situation.

MR. KENAGA: I share your fears. I repudiate the idea though that this magazine is an official spokesman for the chemical industry.

Many chemical industries have nothing to do with agriculture. Many farm industries have nothing to do with individual chemical companies. Yours is a very broad statement.

I am sorry that people make statements which are so strong, but this is their decision; this is the editor's decision. I don't believe that any chemical industry stands for and makes policy for the other members of the industry. I don't think that you can say that there is an official stand taken by the entire chemical industry.

I would like to state furthermore, when you are talking about DDT and other materials like that, that they are made only by three or four of the 90 or 100 pesticide manufacturing companies. I am talking about the raw materials and not the formulations.

MR. BECKMAN (New York State Legislator): In West Germany it was agreed they were going to phase the undesirable qualities out.

I am wondering if that same principle has application in our pesticide industry, if we could say that such and such quality, such as that defined in DDT, is undesirable and three years hence it shall be unlawful to market such a type of pesticide. Would you comment on the possibility of that?

MR. KENAGA: We would like to have a pesticide hit a target and then just disappear. However, the target for pesticide use, be it for a plant or some insect, may require a persistence to do that job for longer than is desirable environmentally.

So the difficulty is in determining how long you want it to last, and certainly there are some compounds which are long-lasting, especially some of the herbicides, which don't have a very widespread non-target effect. And yet they are persistent and in the monoculture of agriculture, in the corn or cotton area, this is necessary in order to make the crop profitable.

Now, I would also say that the chemical industry thinks in part—and here I am using the term broadly because I do not speak for the chemical industry; I speak for my own and a few other companies that have this attitude—the compound should be able to last for one year or so, and then it should be gone. There is no need for it to last indefinitely except in specialized cases as where you have timbers that need protection from termites and couldn't get at them readily. So biodegradability half life would mean one day to say 90 days of the growing season for that particular crop being treated.

It is easy to get short degradability and it is easy to get something to last a long time. But to get something to stay where you want it is very difficult.

So the whole problem is in trying to measure what you want to get in biodegradability. We have all ranges of biodegradabilities in the pesticides arsenals. Everything you can think of. It isn't that we don't already have biodegradable pesticides.

I am not sure I answered your question, but I tried.

DR. F. M. BAUMGARTNER (Wisconsin): I would like to make one comment on Dr. Kenaga's discussion of the fact that it does take a lot of time and it is a very pesky process to come up with the idea of the new chemical compound that may be effective as a pesticide or insecticide.

It seems to me that with all of these scientific facilities we have to field test materials and what we know today of the effects of the so-called hard pesticides would strongly suggest that any materials of a similar nature should be researched with our present-day knowledge of magnification of hard pesticides and the very subtle effect they may have. If at some fairly early stage in the development of these chemicals these materials could be phased out as has been the common practice of the chemical industry, we might be able to head off the terrible problem we have had after these materials have been on the market many years and we have taken a good hard look at their effects.

I realize that in many cases it takes a long-term research program to determine the ultimate effect of some of these things. But now that we have had enough experience—Dr. Johnson and many others with DDT—to recognize that if something is likely to have some effect on the environment, there should be some indication of this fairly early in the game.

But as we all know, in the past, if an insect control program was being started, maybe the day before it started a biologist or ecologist just happened to pick up the fact that the program was going to get under way.

I was involved in two of these in Oklahoma. I got a half day's notice that something was going to be tried.

MR. KENAGA: I appreciate your comment, but I would like to call upon the grandfather clause again. I think we are today talking about DDT and the chorinated cyclodiene type of compound which were introduced as new insecticides in the 1940's.

I would ask you to think that since that time, many insecticides have been introduced into the market, and few of these are of that type of compound that accumulates in tissues. We now have many new compounds being used which do not have the problem which you are speaking about.

So, I realize it is a difficult situation. It is unfortunate it took us 20 years with a material as commonly used as DDT to find out what the real problems were.

DR. COWAN: I might make a comment here, that although Gene represents the thinking of a few of the companies in the chemical industry, somebody has to be buying this material or they wouldn't be manufacturing it. And if they buy it, they are going to be putting it to use. Maybe we should direct some questions to one of the major use agencies, and see what they have to say. I see Charlie Black wants to ask a question.

DR. BLACK (Michigan): I am not going to write my Congressman, Gene, but one thing does bother me.

Way back in August, 1962, the U.S. Forest Service came out with a report based on research indicating that methoxychlor was a safe and effective substitute for DDT in Dutch elm disease control. Yet in Wisconsin, and also in Michigan, it took six years for the people to finally come out recommending it in place of DDT. Now, there is a credibility gap of six years.

Why has the chemical industry dragged its feet on an issue such as this?

MR. KENAGA: This problem is quite complicated. I would just like to say that the U.S. Forest Service has no single agency which studies the Dutch elm disease in depth to try to find a replacement for DDT. Part of it is because study of the effects of disease upon elm trees is difficult. It is not subject to screening tests directly, and I know of nobody who has really developed a good screening technique for it. This means then, that if there are no governmental agencies responsible for studying it, no research gets done.

In the meantime, DDT worked, and DDT was used to try to help stop the spread of the Dutch elm disease westward.

This is a rearguard action, I am sure, and when you ask about methoxychlor as a substitute for DDT, I would say in the first place its effectiveness really wasn't well proven; secondly, in use, it was not very persistent; and thirdly, in Michigan it was only in the last year or two that the complicated techniques were developed which made this a practical thing to do. I might even say that the chemical company making methoxychlor did not push it for that purpose. So it is rather complicated.

When you don't have responsibility assigned for a specific disease, nationally or statewide, then you don't get the job done very fast, and emotions build up because the answer isn't forthcoming. You sit and grind your teeth waiting for a good answer.

DR. BLACK: Gene, the du Pont salesman was in my office back in 1962 or 1963 with a brochure telling how good methoxychlor was in controlling Dutch elm disease. So you can't say it wasn't being pushed. But apparently the people who were pushing DDT were just pushing a little harder.

MR. KENAGA: Well, we are getting into an area which I really don't care to discuss. Because I don't know what du Pont's policy really was. I, too, asked them about it and they said they were not developing it.

MR. JOHN ANDERSON (Connecticut): It seems to me our discussion has avoided saying that the reproductive rate of the insect is so very rapid that they can produce strains resistant to our pesticides faster than you can produce new pesticides.

We have also avoided mentioning the contention by Dr. Milvus that when you increased the food supply of an organism, including the human organism, that population will merely increase to the point where it uses up the available food supply. And it appears then that in our fight man has only fought the insect to a draw. And with that and our enemy "starvation," we appear to be making very little progress.

In view of the cost of our pesticide program, not only in dollars, but in aesthetic and spiritual values, in view of the fact we don't seem to be winning the war against either insects or starvation, it would appear to me that it is time we looked to some other tools in our struggle against the insects, instead of placing all of our faith in insecticides.

DR. COWAN: Would any other of you gentlemen of the Panel wish to comment?

DR. MOORE: We have been looking for alternatives for 50 years. In fact, it is a little ironic our big emphasis on research in chemicals didn't come until the recent pesticide conference. Before that, our effort toward insect research was spent on some form of biological control.

We have major research laboratories looking into the cause of diseases. For instance, viruses and bacteria. I wish we could say that this is going to solve many of our insect problems tomorrow, but that is not the case.

In one case, it is encouraging. In fact, the research on virus disease for tussock moth looked so good we stopped all research on chemicals for this insect. I would like to see more of this.

I think certainly as I say in forestry, we have been looking into these other possibilities for a good many years. The opportunity for using them has been all too small. I hope to see more of them.

FROM THE FLOOR: Dr. Kenaga, you seem to be catching all of the heat, and my question is also addressed to you.

It is, frankly, the kind of rhetorical question we have been hearing all afternoon. But what I would like to convey, and I think I may speak for more than a few people here, is that the reason, of course, Dr. Kenaga is catching it is there are a large number of concerned people; the issue of the credibility has been already raised, and this is really what is at stake.

We have experience, we have experience now going back to the 1940's. A suspect group of chemicals has been persistently pushed in the political arena, in the administrative arena, where millions of dollars have been spent resisting change, trying to stay with the status quo. Then the credibility of the industry is at stake, and, of course, they realize that. That is why Dr. Kenaga is here.

But I hope he goes back home to Dow Chemical and tells them their credibility is indeed still at stake. (Applause.)

MR. BLACK: I would like to come to the defense of Gene Kenaga. Gene is very much interested in the same things that we are. He is a member of the Audubon Society and has been president of the Michigan Audubon Society. So he knows the way some of us are thinking. I think from his position as an employee of the Dow Chemical Company, and his interest in the outdoors and wildlife, he was up there with mixed emotions. (Applause.)

MR. PARKE BRINKLEY (President, National Agricultural Chemicals Association): I represent the manufacturers of pesticides. I came here today, not with the idea of saying anything, but of listening.

I would like to take just a minute to say to you, if I may, that I am a practicing conservationist, I am a practicing hunter and fisherman, I spend as much time doing this as a great many of you. I certainly have fully as much love for it as any of you.

I also happen to know well the attitude of the chemical industry. I would like to say to you that we are extremely interested in these problems that you talk about. I would like to say to you that we have repeatedly invited the wildlife interests to sit down and reason with us, and I again issue this invitation: Bring your facts and put them on the table and let's look at them, away from the television, radios, and the newspapers and sit down and talk reasonably about this.

As Dr. Kenaga told you, the emphasis for a number of years now has been away from these compounds that you keep talking about. And the use of them is going down hill all the time. I would still like to say to you that there are many of these same products, DDT being one of them, that has a great many very fine uses. And you are going down the wrong path when you are trying to get rid of all of this in one fell swoop. I don't think you want to do that. I think you want, like the rest of us, to prohibit those uses that are damaging.

By the same token, I don't think you want to get rid of them. You also get rid of the uses of these materials that are perfectly proper, perfectly safe.

DDT is, of course, the grandfather of all of them. But DDT is a product that has saved a lot more lives than penicillin or aureomycin. It has done a great deal of good. Let's not look at it as being something that is all bad. Let us look at it on a reasonable basis: come in and sit down with us if you would like to talk about it.

We would like you to help us get better answers. We would like for you to help us point up the problems, and I guarantee to you that we in the chemical industry are ready to sit down and help you if you will sit down and help us. Thank you.

DR. J. J. HICKEY (University of Wisconsin): I was glad to see my friend Gene Kenaga identified as a past president of the Michigan Audubon Society.

I should identify myself as having done 11 years of research on DDT. I think my present position is now identified by a chemical industry author as representative of that group which has "a fear of impending sexual impotency and to whom the subject is never uttered in jest."

I found as an expert witness at the Madison hearing, that it was personally insulting to me to have the pesticide task force of the National Agricultural Chemical Association have a lawyer representing them who was the author of the quotation that I just made. I regret that I have not had the personal pleasure of meeting Mr. Brinkley and talking over our problems about DDT.

I can report to him some of the experiences I have had with his association in Madison, when the executive director of the National Agricultural Chemical Association testified at length at a hearing in about 1960. I had the embarrassing obligation to stand up and accuse this man of a direct falsehood.

When I had to appear before a Legislative Council hearing at which a member of the Association appeared and distributed literature, I had the difficulty of having to go back and spend a half a day analyzing this literature and reporting to the executive secretary of the Legislative Council that the Association was again making these statements.

This is past history, and I don't hold this at all against you, Mr. Brinkley. But let me point out that the ecological investigation of DDT as a persistent chemical has had a thorough study by ecologists. We have pinpointed the worldwide prevalence of this compound as an environmental pollutant. We have traced it through the ecosystems. We have found population effects that are catastrophic.

We have had scientists who have run carefully controlled experiments and absolutely shown that 3 ppm of DDE will produce substantial physiological changes which we are measuring in the wild. We have documented this historically. We feel, who are working with this chemical and its effect on the environment, that any use of DDT in the field is wrong. It gets into the world environment, it passes from one continent to another. DDE is found at a level of 17 parts per billion in dust coming across the Atlantic from Africa, it has been found in the rain of 8 States that were traced to Britain.

What we use in America in terms of DDT will have effect on other continents. The fallout pattern, I might add, is not precise, but if we are to use DDT in any specific practice, I think it is up to the industry to show that this particular usage is not contaminating the environment and having population effects which are unprecedented in ecology. It is your responsibility.

MR. KENAGA: I have been on quite a few pesticide relations committees, and it sounds like starting all over again. I believe that part of the problem—and I identify it myself—is that the agriculture people look at DDT as a boon to mankind from health and food standpoints. So far, we haven't proven that it hurts humans directly and ecologists look at it from an entirely different, environmental viewpoint. They say it is damaging the small organisms.

So somehow or another these two groups don't meet on common ground. It is partly, I feel, that both are trying to prove their case in a strong defense against the other. It is to me a rather typical human reaction.

The World Health Organization was formed to protect our health, and it is the one which uses a great amount of DDT in the world. If you want to talk about DDT contamination, it is going on at a faster rate overseas than it is here in the United States. So it needs to be taken up at some very high level. We are not talking about industry, we are talking about Government and people who use these materials.

I am not trying to get out from underneath anything that industry does. I am only trying to point out to you it takes more than industry. As you say, it takes two to tango. There is more involved than just one segment of our industry. How to get at this is a very difficult problem.

DR. COWAN: I am afraid that I am going to have to bring this extremely interesting discussion to a conclusion. I know that we could spend the rest of the night here and some people would never even get close to the other side of the coin.

I think that it is extremely important for all of us as scientists to recognize that there are two sides to this coin. I am not going to try to tell you whether one side or the other is right; but we do have to be careful in our considerations of these matters, that we do not go just as far off on one end as we claim the other people are going on their end.

TECHNICAL SESSION

Tuesday Morning—March 4

Chairman: Richard H. Cross, Jr.
Chief, Game Division, Commission of Game and Inland Fisheries, Richmond, Virginia

Discussion Leader: David B. Vesall
Game Section Supervisor, Department of Conservation, St. Paul, Minnesota

---

FIELD AND FARM RESOURCES

HUNTER—LANDOWNER RELATIONSHIPS

James S. Durell
Department of Fish and Wildlife Resources, Frankfort, Kentucky

Professional wildlife managers and hunters are endangered species. Both, like the whooping crane, are more and more being crowded onto special reservations—our state-owned wildlife management areas.

This presentation constitutes a series of challenges to wildlife professionals:

—to remove ourselves from reservation status, dircting our concern toward management on small private landowner holdings where the hunters are, rather than toward more restricted state-owned wildlife management areas, which are accessible to fewer hunters;

—and to see that more ***hunting*** per game management dollar is more important than more ***game*** per dollar.

To meet these challenges, we must have a better understanding of hunter-landowner relationships. To understand these relationships, we need to correct some stereotyped ideas we have about the hunters and landowners with whom we work.

Hunters

The word "hunter" creates a mental picture for each one of us. Unfortunately, the picture is often an inaccurate one, formed by our experiences in collecting game data from hunters in the field (usually the best hunters, in the best areas) and by our contacts with sportsmen's club members—the more enthusiastic and more skillful hunters.

A more accurate picture comes from the 1965 National Survey of Fishing and Hunting (USDI, 1966) which shows that 41 percent of all hunters hunt less than three times a year. This fact, a vastly significant one, holds even though substantial hunters average 13 trips a year and the average substantial hunter makes about eight trips.

An indication of where these hunters do their hunting is provided by another study of licensed hunters (Durell, 1968). The hunter's home county provided 72 percent of all hunting trips during the 1963-64 season in Kentucky.

Further, some 84 percent of all licensed Kentucky hunters were either landowners or had access to hunting land owned by relatives or friends.

This figure—probably nine-tenths of all hunters when you take into account those who hunt their own land exclusively and, in Kentucky, may do so without a license—represents what is perhaps the most significant mistake we professionals have made: producing more game per dollar in public hunting areas and leaving out of the picture the vast majority of all hunters—those who already know where they can hunt and would hunt more there if only there were more game.

So, we have a vastly different picture from our standard stereotype of hunters and those we read about in outdoor magazines. Our average hunter hunts only about four days per year, most often in his home county and either owns land or has close relatives or friends who own land.

In reality, the gulf between hunter and landowner is not so wide as we might think: most hunters have access to land on which they could produce more game for themselves if only the wildlife professionals would reach them with a management program.

THE GREAT WHITE FATHER'S CHOSEN PEOPLE?

"Landowner" like the word "hunter" calls up a mental picture for each of us. The picture imprinted in the minds of biologists and some hunters is strongly colored by the wildlife habitat destruction carried out by farmers. They drain swamps, bulldoze good wildlife cover, and plant pine trees in badly needed forest openings. We have a tendency, too, to believe that foresters and agricultural scientists are a little overzealous in encouraging farmers to do these things.

Even though these and other soil-conserving practices are normal production methods which contribute to the farmers' income, many of them are subsidized by the Federal Government. The government also guarantees prices on some farm crops. It looks as though farmers really are the Great White Father's Chosen People.

Their net income, though, is the best indicator of just how much farmers are pampered. In 1965, Kentucky had 133,038 farms. Their average gross income was $5,584, including $300 in federal payments. Production costs averaged $3,675, leaving a net income of $1,909 (USDA and Ky. Dept. of Agric. 1966). This is not quite as bad as it sounds, because other sources of income brought in about $2,000 per farm (Fulmer, 1966). Here again, reliable statistics about an entire group of people (farmers) show just how wrong we can be in developing a mental picture of the average.

This low income is a factor biologists seldom consider when thinking about farmers and agricultural programs. Is $4,000 per year really too much for a farmer to earn? Can we really blame a forester or soil conservationist for trying to help farmers increase their income?

We naturally hate to see wildlife habitat destroyed. But every 10-acre patch of brush or weeds represents a significant investment. Whoever owns it is entitled to some kind of return. Perhaps the wildlife profession should devote more effort to persuading these landowners to seek part of their return in rabbits instead of dollars.

Even if we are not impressed by the economic plight of farmers, we should recognize what they do for game management. The privilege of hunting on their land, not the hunter's license fee, is the basic resource which supports our state game management programs. Most hunters buy licenses only because they expect to get their money's worth of hunting recreation. In Kentucky, 92 percent of this hunting is on private land (Durell, 1968).

We also forget that farmers are our best customers. Twenty-eight percent of them are hunters compared to 14 percent of the entire labor force. In towns and rural areas, 14.2 percent of the entire population are hunters, compared to 3.4 percent of big-city populations (USDI, 1966).

Most urban hunters probably come from farms or are only one or two generations removed. Urbanization apparently discourages hunting.

Federal agricultural programs have complex economic and sociological effects. Like game management programs, they are subject to criticism by all citizens. Game management is often unjustly criticized by people who simply do not have the biological background to know what should be done. This criticism helps to keep us on our toes, but we resent it when it interferes with sound game management.

Therefore, it behooves us to be cautious in criticizing programs developed by other technically trained people.

Price supports for farm crops pose a question which probably will be debated from now on. There is widespread feeling that these price supports should be discontinued and the larger, efficient farms allowed to squeeze out the less efficient ones. Not even the economists and sociologist can prove what consequences this would bring about. But State game management agencies would suffer in two ways if this should happen. Many farmers would be bankrupt and would not buy hunting and fishing licenses. Presumably, they would move to town and get other jobs. But as they move on to large cities, three-fourths of them quit hunting and buying hunting licenses (USDI, 1966).

A second loss would occur because efficient farming means wildlife habitat destruction. It doesn't have to, if a farmer is willing to sacrifice a little efficiency. But if he's trying to grow corn for 70¢ per bushel, he probably will leave very little wildlife cover for our work.

GAME MANAGEMENT POLICIES

Our rapid trend toward urbanization and the low percentage of urbanites who hunt suggest a continuing decline in hunting.

To preserve hunting as a type of mass recreation, we must provide enough game to attract hunters within a distance they are willing to travel. However, a current basic philosophy in game management is to concentrate money and efforts where they produce the most game per dollar. This often produces excellent hunting in areas so remote that only a small percentage of hunters consider the hunting opportunity worth the trip.

Small game provides 69 percent of the hunting in the United States, while big game provides 24 percent and waterfowl 7 percent (USDI, 1966). Table 1 shows that small game provided 95 percent of the hunting in Kentucky (Durell, 1964).

Despite this distribution, most game management effort is directed toward big game and waterfowl. This does give us more game per dollar, but actually is taxing the less fortunate majority of hunters to benefit the fortunate minority who live near waterfowl and big game areas, or who can afford to travel there.

TABLE 1. DISTRIBUTION OF HUNTING PRESSURE IN THE UNITED STATES AND IN KENTUCKY

	Percent of Hunters		Percent of Trips	
	Kentucky	U. S.	Kentucky	U. S.
Small Game	99?	78	95	69
Big Game	10	49	3	24
Waterfowl	3	13	2	7

In 1961, Kentucky spent about $80,000 on waterfowl management (Durell, 1965). This was about four times as much as the license fees of all waterfowl hunters in Kentucky. The only place to get this extra money is from hunters who buy licenses but get little or none of the game management budget.

There are some good reasons, though, for deer and waterfowl to receive more effort than their proportionate share of the game management dollar.

In 1961, Kentucky waterfowl hunters averaged 32 hunting days each, including hunts for all other species (Durell, 1968). This was twice as many trips as the average for all hunters. Such individuals as these contribute more to the P-R fund and are more likely to continue buying hunting licenses. As individuals, they deserve more consideration than the incidental hunter. The question is, who should have to pay this extra expense? How long will the great mass of incidental hunters continue to support these programs which they do not utilize?

There is a widespread feeling that farmers will try to produce more game only if it adds to their bank accounts. This is not consistent with the high percentage of farmers who hunt. Neither is it consistent with farmers' other non-profit endeavors, such as supporting churches, raising children and giving money to charity. If we assume that they devote all their energies to making money and only come up with $4,000 per year, we are not very complimentary.

Wildlife and hunting can benefit a farmer in so many ways that we should be able to persuade a high percentage of them to include it in their programs. If we can't, hunting will become a sport of privileged minority, and the game management profession, as we know it now, will cease to exist.

ACKNOWLEDGMENTS

I am grateful to the entire force of conservation officers in Kentucky for obtaining hunting license samples and finding and interviewing hunters from 1959 through 1966. Mr. William C. Wodraska made many helpful suggestions during the preparation of this paper. I am especially indebted to Game Director Arnold Mitchell for providing the necessary staff and other factors essential for carrying out the hunter surveys.

SUMMARY

A current philosophy of concentrating the game management budget where we get the most game per dollar is neglecting the potential hunter who is not willing to travel far beyond his home

county. The importance of this small-game hunter, or potential hunter, has been camouflaged by a false impression of the entire hunting population.

Thirteen was the average number of trips per year for the "substantial" hunters in 1965. But the median was about four for all hunters. In 1963, 72 percent of all hunting trips in Kentucky were in the hunter's home county. Eighty-four percent of the licensed hunters either owned land, or hunted part of the time on land owned by relatives or close friends.

Kentucky farms averaged a net income of $1,909 in 1965. Federal agricultural programs permit many of these small scale, hunting-license-buying farmers to stay in business. If they were forced into large cities to find employment, 75 percent would quit hunting.

LITERATURE CITED

Durell, James S.
1964. Past hunting season. Happy Hunting Ground 20(6): 20-22. Ky. Dept. of Fish and Wildlife, Frankfort.

———— 1965. A study of Kentucky hunters who hunted only in their home counties. Proc. 16th Ann. Conf., S.E. Assn. of Game and Fish Comm. 16: 171-175.

———— 1968. A brief study of hunters and the owners of the land on which they hunt. Proc. 21st Ann. Conf., S.E. Assn. of Game and Fish Comm. 21: 81-87.

Fulmer, J. L.
1966. Development potentials for Kentucky counties, with related statistics. University of Kentucky, Lexington.

U.S. Dept. of Agric. and Ky. Dept. of Agric.
1966. Kentucky Agricultural Statistics, 1965.

U.S. Dept. of the Interior
1966. National survey of fishing and hunting 1965. Resource publication No. 27, 76 pp.

DISCUSSION

MR. WILLIAM CASEY (Kentucky): You said most hunters have access to land on which they could produce more game for themselves if only the wildlife professionals would reach them with a management program. Later you said most game management effort in Kentucky is directed towards the big game and waterfowl. Just what is the Kentucky Department of Fish and Wildlife Resources doing in farm game management and why don't they spend more money on it?

MR. DURELL: We provide technical assistance to any farmer or ranch owner who requests it. We will send a trained biologist to go over his farm with him and tell him what he can do to produce more game. I think you are aware we don't get a lot of requests for that type of help. I believe that is true in most of the eastern states.

Further, many people here are familiar with the farm-game programs that were very popular in the Southeast ten or fifteen years ago, which emphasized distributing plants and seeds to farmers. However, a lot of you know how ineffective those programs were. Personally I am not convinced that failure to do something proves that it cannot be done. I hope in the future we will be able to do more of this.

MR. DWIGHT SMITH (Colorado): Early in your talk you mentioned that you did not believe it was possible or reasonable to expect farmers who perhaps make a total of $4,000 a year to do a great deal for wildlife management with no economic returns, and I agree with you. Later you indicated that unless we were able to convince the farmers that they could assist us by producing wildlife for other than economic reasons, the wildlife profession was indeed going to have reason for concern.

Do you have any programs in Kentucky in which you endeavor to train or give information to landowners to assist them in developing wildlife enterprises for economic reasons because, as I indicated, we in Colorado feel that we do have to have some type of economic return for the landowner.

MR. DURELL: We do not have the type of program you describe. Landholdings in Kentucky are so small that possibilities for economic return are light, except for people who go into commercial shooting preserves. We have only ten of these in the state and most are not doing too well. I did not mean to imply that we should not expect to persuade farmers to devote their efforts to wildlife without economic return. There are many reasons other than economic returns which should induce farmers to grow more game. In fact, I know of one elderly farmer who complained that none of his grandchildren or in-laws ever came to see him. However, these people always manage to drop around on the first weekend of the hunting season.

MRS. WILSON: Is there any provision for nature study in the areas close to urban centers?

MR. DURELL: No.

MR. VESALL: You mentioned the need of developing lands near metropolitan areas to preserve hunting as a mass form of recreation. Should we not think about preserving and setting up areas for the hunters who like to travel a distance for quality hunting purposes?

MR. DURELL: In Kentucky most of our effort is actually going for that type of hunting. We are concentrating on public wildlife management areas. We have 40, including some as small as 125 acres and one of a half-million acres and are providing high quality hunting on a great many of them.

MR. VESALL: In your paper you mentioned that we have to be careful about criticizing other technical personnel who are in related resource programs. This is well and good, but I think that there are cases where a little criticism in the right place can do a lot for our resources.

MR. DURELL: Yes.

MR. FRANKLIN DUGAN (SCS Biologist, Virginia): Since this paper was on hunter-landowner relationships, I am sure you were not concerned with nature study for urban children. However, I want to point out that the Soil Conservation Service biologists, at least, are very much interested in this angle, and we are moving into urban and suburban work. We can point to many cases where private landowners have made their land available for educational and charitable study of nature and wildlife. I recall, for instance, some farm ponds which have been made available for special trips for urban schoolchildren to spend a whole day fishing and learning about wildlife and fish management. We also have other areas that are being developed for nature trails, outdoor laboratories, etc. I merely wanted to assure the lady who asked the question that this phase of the wildlife conservation program is not being completely overlooked.

PRIVATE LANDS FOR PUBLIC RECREATION: IS THERE A SOLUTION?

CHARLES H. STODDARD
Wolf Springs Forest, Minong, Wisconsin; and

ALBERT M. DAY
Camp Hill, Pennsylvania

At all levels of government, the competition for public funds is such that their availability for the acquisition and development of land for recreational use is limited. Furthermore, there is a limit to the amount of land which can be taken out of private ownership for this purpose. It is important, therefore, to find formulae for unlocking more private lands suitable for public recreational use under arrangements suitable to the owners and public alike.

Recreational use of private land can be divided into two types of situations: (1) *Extensive* recreation use, where the land and water areas themselves provide recreational activity opportunities, such as hunting, hiking, canoeing, fishing and tent camping, but are also used for such economic uses as forestry, livestock grazing, and agriculture. A related consideration is the availability of access routes across privately-owned lands to public recreational areas; and (2) *Intensive* recreation use, wherein the land and water areas are primarily dedicated to recreational pursuits and are heavily developed, requiring substantial investment in facilities and supporting services. Examples of this type are private campgrounds, summer resorts, shooting preserves, recreational park complexes with full development of golf courses, pools, riding stables, fishing waters, etc.

Because of the mounting demands for outdoor recreation and limited public land areas, this study of recreational possibilities on privately-owned lands concerns itself with extensive recreational land uses. Suggestions for removing major obstacles to access by recreational uses which have prevented any significant development of such use in this important segment of our land base until now are set forth in this paper.

Three-fourths of the land in the United States is privately owned. Most of the remaining one-fourth is owned by the Federal Government. These federal lands, open by law and policy for recreation, lie for the most part west of the Great Plains, while the masses of recreation seekers live mostly east of the Mississippi River. If this gap between demand and supply is to be bridged, and the predicted three-fold increase in demand for outdoor recreation during the next three decades is to be satisfied, suitable access arrangements to and facility development on private lands must be accomplished.

Land ownership patterns vary. In the western states there are, in addition to the public lands, large blocks of land in private ownership: livestock, ranches, tracts of timberland and, in irrigated valleys, farms and orchards. But much of the public domain, theoretically available for public recreation, is separated from the avenues of access by privately-owned lands lying at lower altitudes. In the Great Plains medium-sized farms and ranches dominate; little of the land is in the public domain. The northern Great Lakes country has both public and private forests and farms, interspersed with thousands of natural lakes and swamps. New England is dominated by small forest ownerships and small, rocky farms, while the South has medium-size farms and large areas of pine and hardwood forests, both individually and industrially owned. In nearly all non-farm areas, absentee ownership is prevalent.

This study is concerned with recreational activities, usually pursued by individuals or very small groups, for the enjoyment of which the participants require little more than access to the land, water and wildlife. Examples of this type of recreation are:

Fishing on streams, rivers and lakes within or reached through private landholdings;

Hunting, particularly for small game, such as quail, pheasants, rabbits, squirrels, 80 percent of which are produced on private lands;

Hiking and horseback riding on established trails through private lands; and

Camping in designated but unimproved sites (with minimal facilities) on private land along rivers, streams, ponds and in woodlots, where the camping is incidental to the above activities.

IMPEDIMENTS TO PUBLIC RECREATIONAL ACCESS

As nearly as can be determined, there are a series of factors which cause landowners to deny the public access to their lands for recreational activities. Most rural private land is managed so as to maximize revenue from income-producing crops—livestock, farm crops, such as corn and wheat, timber or other commodities—and *not* for such intangibles as recreation potential, wildlife production, watershed conservation and scenery. Thus there has been a negative economic incentive to landowners to consider these intangibles in their land management programs.

While lack of income from most extensive recreation activities is an important reason why landowners are reluctant to open their land for public recreational uses, a number of other factors also tend to dissuade property owners from permitting hunting, camping, fishing and hiking on their lands. Traditionally, recreational uses—with or without permission—often have resulted in damage to the property by a thoughtless minority. Damage to fences and trees, livestock, and littering, etc., create an expense or economic loss to the landowner without producing any offsetting revenues. Collection of user fees by owners of small tracts of lands has proven impractical and more expensive than revenue obtained. In addition, many state laws hold landowners liable for accidents taking place on their premises. (Some states have enacted laws exempting landowners from personal liability.)

This lack of economic incentive from recreational and other use and the distinct liabilities resulting therefrom tends to encourage landowners to obtain maximum revenue from commodity production and to post lands against trespassing. Indeed, wildlife habitat in fencerows and woodlots is often cleared and wetlands drained specifically to remove their attractiveness to hunters as well as to increase farm income. Furthermore, small tracts—farms and forests—are inadequate as single units to provide for most extensive recreational needs, and are usable for such purposes only when grouped into larger management units.

A special problem exists in the western states, where access to public domain or national forest land is often blocked by private holdings lying at lower altitudes and adjacent to roads and other avenues of access. Recreationists crossing these private lands to reach the public domain and national forests often damage private roads and trails, destroy fences, and cause vandalism.

A final major obstacle is the traditional open-land philosophy of the American people. The pioneer attitude of free access to the frontier has carried over to the present, and many people feel that open country is available for their use regardless of property lines. This attitude would be changed by arrangements for responsible access.

PAST AND CURRENT EFFORTS TO RESOLVE THE PROBLEM

Over the past 30 years many state conservation departments and voluntary local groups have developed a variety of plans which have attempted to solve one or more of these obstacles.

Access Arrangements:

State Agency Sponsored: The most successful state agency plans are those based on systematic, responsible access arrangements requiring landowner permission. Under agreement, signs establish "safety zones" around buildings, livestock enclosures and pastures and special crops, while "Access by Permission" signs specify the land open to the public. Violations of these established "safety zones" are enforced the same as other game laws. Some states revoke the violator's hunting license. In addition, some states provide the landowners with wildlife planning assistance and furnish him with food and cover plants. Practically none, so far as we have learned, has any arrangements for revenue compensation to the landowner.

In return for these services, the landowner agrees to keep his land open for public use. These arrangements have been instrumental in opening substantial acreages for public use. Pennsylvania, for instance, has since 1936, restored to public use more than 4,000,000 acres of once-closed private lands.

Voluntary landowner—sportsman-sponsored: Because small single tracts are inadequate for most extensive recreational uses, various groups and organizations have endeavored to improve landowner-sportsman relations through various types of exclusive access plans. One type of arrangement which has been fairly successful in a few places is for an organized sportsmen's association to lease the hunting or fishing rights to a block of land ownerships, often through either a local farm organization (Grange, Farmers Union, or Farm Bureau) or a Soil Conservation District. Collection of fees and payments is made by the sportsmen's group and turned over to the landowners' group, which apportions and distributes the funds to the individual landowners.

Most other voluntary programs are limited to public relations efforts to encourage more responsibility on the part of the sportsmen, better outdoor manners, and, in return, more friendly and cooperative attitudes on the part of the landowner. The best-known of these efforts are:

HAT (Hunt America Time), sponsored by the Izaak Walton League of America, the National Sporting Goods Association, and Olin Industries (a major manufacturer of sporting ammunition), which concentrates on improving hunter behavior;

FAIR (*Federation and Industry Program*), developed by Olin Industries and the National Wildlife Federation, which seeks to foster initiative by local sportsmen in developing out-of-doors recreation on lands that are open to hunting by permission;

Operation Respect, in Colorado, which tries to involve both hunters and communities in good conduct on the part of sportsmen;

Howdy, a program of the Pennsylvania Forestry Association symbolized by a friendly raccoon preaching good sportsmanship, which reaches one million school children and hunters each year; and

Forest And Other Industry Programs. Increasing use of private company lands for recreation is revealed in a recent survey conducted by the American Forest Institute. The American Forest Institute, sponsor of the American Tree Farm System, conducted a study which follows up three earlier surveys dating back to the 1950's made by the old American Forest Products Industries, Inc., predecessor of AFI.

Not unexpected, the new survey shows most industry lands increasingly open for hunting, camping, picnicking, and trapping. Waters within these lands are also available for boating, swimming and fishing. Trends revealed by comparison with the three earlier surveys: more land open to recreation, more companies charging fees for recreation use, and more companies publishing descriptive literature about the kind of public recreation available on their lands. More companies reported employing recreation specialists and making long-range plans for the recreational development of their properties.

The 234 companies surveyed reported 122 company parks, 191 picnic areas and 175 company-built campgrounds. These improvements have a combined visitor day capacity of nearly 29,000 persons—or 10,585,000 persons annually. In addition, the companies provide 12,011 acres for the operation of 714 picnic areas and campgrounds operated by state and other public and quasi-public agencies.

In all, the survey showed 93.3 percent of the industry-owned and leased land available for one or more public recreational activities. More than 95 percent of the companies said they opened their lands for the public to use and enjoy.

The survey totals revealed annual recreation expenditures by the companies to be $7,038,850. However, vandalism costs totalled $436,070 as a result of this public use, including such items as signs destroyed, garbage dumped, theft, damage to company equipment, property, and roads, and starting forest fires. Only 1/10 of the 234 companies reported making a charge for their recreation facilities.

Although data on electric utility lands are not readily available, it is known that many are opening their lands to recreationists. A recent outstanding example is the Northern States Power Company, which not only turned over its lands bordering the St. Croix River to the National Park Service for the new Wild River, but opened its other reservoir lands to public use.

INCOME FOR LANDOWNERS

Individual landowners find that the collection of fees from occasional and seasonal users is generally impractical. Although no complete canvass of the various local efforts has been made, several interesting plans have been brought to our attention.

In Washington, local Granges organize groups of farm members and collect substantial sums of hunting fees.

In Ohio, the members of a rural parish have for many years leased their pheasant hunting rights for a sufficient fee from hunters to build and maintain their church.

In Texas, large ranches are leased to sportsmen's groups for substantial sums.

In Colorado, a Soil Conservation District arranges pheasant hunting, including room and board, for cooperating hunters.

In Wyoming, some ranchers controlling large acreages make substantial supplementary income from hunters. In some cases, they use their base ranch lands to control access to intermingled public lands, a practice not considered in the public interest.

STATE PROGRAMS FOR ACQUIRING ACCESS RIGHTS

Most states emphasize publicly-controlled areas. ***Purchase*** in fee title is preferred, but *easements* and *leases* are also employed, especially for access to streams and lakes or other public areas. State public hunting grounds on leased private lands with daily fees are given special attention and some are regularly stocked with game. Wisconsin has, for many years, leased private lands for 30 to 50 cents per acre per year for public hunting. In addition, the state assumes legitimate hunting damage claims.

LAWS TO LIMIT LANDOWNER LIABILITY

Several states have enacted legislation limiting the liability of landowners for damage claims resulting from public use of their lands. These laws, which have been adopted by about one-half of the states, are patterned after a model statute developed by conservationists and sponsored by the Council of State Governments.

In most states, however, the landowner's liability for personal injury to the recreationist or property damage is measurably increased when a charge is made for entrance, or for hunting or fishing rights. Many landowners are reluctant to enter the paid recreation field until the personal liability situation is improved.

EVALUATION OF PAST EXPERIENCES

While the many efforts to resolve the problem have attempted removal of one or more obstacles to public access, it is clear that none has been combined into a completely comprehensive program. None of the plans to date has either stopped the wholesale rash of "No Trespassing" signs or brought about any basic change in landowner resistance. As a result, little substantial progress has been made. Each plan, however, contains elements which could be combined in several ways to remove obstacles and create incentives for systematic access.

Any successful plan to allow public use of private lands must provide for most or all of the following:

Request by the recreation user for permission by owner for entry and use;
Relief of owner from liability for accidents occurring as a result of recreational user access;
Responsibility by recreational user for damage to landowner's property;
Revenue to landowner for use of property by recreationists;
Creation of a manageable unit by grouping adjoining ownerships; and
A public information program to encourage good outdoor manners and to clarify the obligations of both recreation users and landowners.

Both private landowners and recreationists are looking for greater leadership from the state conservation agencies that hold responsibility for licensing and supervising outdoor recreation facilities. There appears to be a definite need for positive official leadership to encourage more private efforts if non-public lands are to meet their share of the anticipated increase in recreational demands.

Purchase of a license to hunt or fish does not carry with it an obligation by the issuing authority to provide a place to exercise the franchise. Yet, because the management of fish and game rests with the states, and 80 percent of the wildlife habitat is located on private land, the obligation both to the landowner and to the recreation seeker to whom the license is sold, appears to be with the states. The relatively poor showing of hunting and fishing in the recreation boom is indicative of the lack of access to private lands by sportsmen. That landowners provide, at their own expense but generally without compensation, the place to hunt or fish has a definite bearing on the problem.

SUGGESTED PROPOSALS FOR PROVIDING RESPONSIBLE ACCESS

Past experience has been so uneven and unproductive of solutions and so little research has been attempted that a few guidelines are available to provide any generally applicable plan. Yet elements of previous efforts could be combined into possible plans for pilot testing and, hopefully, development of ultimately workable solutions.

Two possible approaches for sponsorship of trial plans are available for consideration—by the state conservation agencies, and by the voluntary cooperation of existing local groups of either landowners or sportsmen or both. Even in the latter case, some supporting state assistance should be available. In the following sections several alternative approaches are sugggested; all should be given pilot project testing prior to general adoption. Accompanying these field trials should be a parallel observation-research program to analyze the effectiveness of the pilot program, determine its shortcomings, and develop modifications and improvements. This first trial phase should definitely precede any full scale effort or general application.

ALTERNATIVE STATE-SPONSORED PROGRAMS

In all cases it is recommended that states which have not enacted laws to relieve landowners of liability for accidents on their lands should do so as soon as possible. This action would remove a major obstacle and create an atmosphere under which the following suggested plans could be carried out.

State Agency—Cooperative Landowner Program

In a defined unit of several thousand acres, composed of a dozen or more ownerships, the voluntary program should include the following arrangements:

Agreement between the state and landowners in which the landowners permit access to their property to all state-licensed recreationists who obtain permission in advance of ingress, post their lands with signs to this effect, and agree to specified arrangements for state compensation. Owners would agree to police the program.

The state agency in turn would agree to assume liability for damage, supply signs to the landowner, provide conservation planning assistance (and possibly undertake habitat improvement measures), and collect a special fee from those recreationists who wish to participate in the program.

Alternative A: Direct State Supervision

This program, following the experience in Wisconsin, would lease (or obtain easements on) several thousands of acres of controllable size for a stipulated annual acreage fee. A state conservation department employee would be assigned to actively oversee the program and the permission arrangements for the owners during the trial period. The hunting and fishing license would carry an extra fee which would entitle the holder to have access to the leased lands. Revenue would be used to defray the program costs; payment of the rental fee to the landowners would be made by the state agency.

Alternative B: State Agency-Local Institution Agreement

Employing the same general features as above, the state would enter into lease agreements with local Soil Conservation Districts to operate the program. State agreements would be confined to owners with signed Soil Conservation District agreements.

RECOMMENDATION

The problem of providing responsible public access to private lands is a complex one involving many relationships and obstacles, mainly soluble at the local and state level. No easy solution is available, or it would have been found prior to this. But the time is here for testing several kinds of arrangements, observing them carefully and refining defects prior to general application.

It is suggested that this is primarily a state-local problem, and that the development of solutions lie with state agencies. The International Association of Game, Fish and Conservation Commissioners, working with the National Association of Soil and Water Conservation Districts, might well sponsor a few pilot projects in selected states and obtain the cooperation of such federal agencies as the Bureau of Outdoor Recreation, the Bureau of Sport Fisheries and Wildlife, and the Soil Conservation Service. A parallel research effort carried on by a state university is needed to measure the effectiveness of the plans and to suggest improvements before general application is attempted. The finding of a successful system would have a major impact in opening up large areas to recreation seekers for these extensive types of uses. Incentives could then be found for landowners to improve recreational facilities and wildlife habitat—thus reversing the "No Trespassing" trend.

DISCUSSION

MR. TED SHIELDS (Minnesota Conservation Federation): I was interested in this. I personally feel we are greatly overemphasizing the problem of hunting access to private lands. I know of only three studies in this regard. One was in Minnesota two or three years ago on crop land adjustment program acreage, in which the study indicated that only 11 percent of the land in this program, private agricultural type land, was not hunted. Also, of this 11 percent, half of that land was not open to hunters.

Another study of a similar type of land in Michigan the following year indicated that over 70 percent of the land on which they made payment of $2 per acre to keep it to hunting had been open the previous year with no payment.

The third study was a recent one on a national basis, which indicated that 87 percent of the undeveloped private land in this nation of private ownership is hunted, and there is little difference from one region to the other.

Using these figures, then, I have the feeling that we are overemphasizing this problem and that we may end up with paid-to-hunt programs that are not necessary. Do you have any comments in this regard or do you know of other studies that indicate the problem is larger than these studies would indicate?

MR. STODDARD: Our paper did not confine itself to hunting alone. I think, though, if you look at the figures, you will find a lot of the hunting done on these lands being done by landowners or their friends. As is generally known, landowners will make this land available under those type arrangements. If you look at big-city hunting figures alone, you will find that they are dropping and for a variety of reasons. However, I do think there is a relationship between the availability of wildlife habitat and the availability of income to the landowner. I think this is the key to our problem—we need to do a great deal more work in providing incentives for landowners to maintain a balanced wildlife habitat rather than use the criteria of economic efficiency as a sole factor in making a decision as to how land is to be used.

MR. SHIELDS: I would agree with that. I would point out one thing—that sometimes we emphasize quality hunting and that most of this private hunting in Minnesota, the study I mentioned, was in relationship to the restriction to other types of hunting. However, in Minnesota, during a normal year, about 65 percent of rooster pheasants are harvested. Private land is being harvested near its maximum by some of the present private owners who allow their friends on it. The land is still being hunted to a high degree as far as quality is concerned. Therefore, even if you paid the farmland owner a great deal more so that they would let people on their land other than their friends, there still would not be much more game to harvest unless they improved habitat.

MR. E. J. HODGES (Washington, D.C.): I would like to give a brief commercial for the American Forest Institute. We have just completed a survey of more than 60 million acres of land in shared use by the timbering industry. Ninety-two percent of that land is available for recreation at this point, despite the fact that it costs more than $600,000 a year in vandalism. Let me suggest you get a copy of this report which can be made available to anyone here from the American Forest Institute in Washington. This has been made available to your Department, of course, and we are working on forage and wildlife in relation to this multiple-use land.

MR. J. DAVID ALMAND (Georgia): First of all I consider that to be a fine paper, explaining the over-all obstacles with regard to recreation, hunting, and fishing on private lands. Certainly this is a problem.

I also thought you said that the collection of fees, both daily and seasonal on small landholdings, was somewhat of a problem.

MR. STODDARD: Yes, but I did not go into the reasons because I summarized my paper. There are so many different points of access that it is extremely difficult to collect daily fees. Seasonal fees under regular arrangement are another matter. This takes regular arrangements to work out.

MR. ALMAND: Probably part of the problem is due to the fact we are all from different areas. I know that in Georgia this is part of the problem, but it is being successfully overcome with respect to hunting certain species of game. Each state has its own problems and this may not be as much a problem, let us say, in Georgia or some other state as in Wisconsin or elsewhere. I was gratified to hear the fact we are pushing toward more free hunting so to speak, but I think we must face facts and those facts are that landowners today have more demand upon their time and operating capital and if we, in turn, expect the landowner to do a better job of improving wildlife habitat and thus, in turn, providing more recreation for the consumer, then I think we ought to realize that he is going to have to expect some economic return. I think this is good. This business of going ahead with pilot programs is something we must do. We have to grab the bull by the horns.

The Extension Service has not been dragging its feet on this, and in one Georgia county we have had a very successful pilot program with respect to hunting, fishing, and other forms of outdoor recreation involving a large number of landowners. I think we are going to pay for the right of hunting and fishing and also expect the landowner to do more to develop wildlife habitat in return for what he is paid.

MR. THOMAS STOCKDALE (Ohio State University): First of all, I would like to compliment you on your paper. You have done a fine job on a tough problem.

However, when I was at Penn State in 1963 we conducted a study of the problem of hunter-landowner relationships and started with a pilot study following it with intensive study of three counties, ranging from rural Sullivan to urban York County. I would like to emphasize what an early speaker said about overemphasis on posting as a problem.

Insofar as I can tell from having surveyed the literature, the extent of posted land has not really changed, and I would say that it still holds true in Pennsylvania. It seems to be around 30 to 40 percent that is closed to hunting through posting. However, our study found (and others also have found) that around 90 percent of the posted land is available simply through permission, mainly through stopping and asking the farmer for permission to hunt on his property.

Therefore, the problem which seems to be largely ignored and which you just barely touched on in your paper was that of absentee ownership and changing land ownership. The traditional landowner is, by and large, willing to permit hunting, but I think we are seeing a new breed of rural landowner, people buying up property as investments or for recreation, and they are not interested in hunting. They realize the economic value of their property, and I doubt very much if they are even willing to form together into cooperatives. They have a vested interest in their property and have no reason to really open it to the general public.

MR. STODDARD: Your point is well made. Many landowners look at land as a chunk of real estate on which they can make a profit by turnover. You are not going to get the kind of habitat manager we are talking about under those situations.

DEVELOPING BOBWHITE HABITAT ON FARMLANDS

PAUL D. SCHUMACHER
Soil Conservation Service, U.S. Department of Agriculture, Athens, Georgia

The bobwhite (*Colinus virginianus*) has been and continues to be the most important game species in the Southeast. Its ecology and food requirements have been the subject of many studies.

Man has manipulated the bobwhite habitat in the Southeast from the time of the first settlers. Up until the mid-1950's, most of the manipulation was favorable to the bobwhite. In more recent years it has been less favorable. The old southeastern land-use pattern consisted of small fields of cropland, pastureland, and woodland divided by numerous fences and hedgerows. This pattern was well suited to the production of bobwhites, as it provided an abundance of food and cover.

In the 1950's changes in conventional farm patterns began to take place. Agricultural programs encouraged the conversion of cropland to other uses and, as a result, drastically changed the land-use pattern in the Southeast. Many acres of cropland, even whole farms, were diverted from cropland and planted to pines. Other acres were planted to grass and legumes. These land-use changes had an adverse effect upon the bobwhite population. When plantation pine plantings are about six years old, the number of bobwhites is reduced. Large fields of grasses and legumes are also poor bobwhite habitat.

A second change in land-use patterns occurred at this same time and continues today. Small fields and pastures with hedgerows and fencerows are combined into large fields or well-kept pastures maintained by machinery or the use of herbicides. This change eliminated many fencerows and hedgerows that had been used as cover and travel lanes by the birds. Although there is probably more food for bobwhites with this kind of farming, the loss of protective cover and travel lanes reduced or eliminated bobwhites.

The Southeast has many landowners who want to produce a maximum huntable population of bobwhites. Some are not interested in income from cropland, pastureland, or woodland but in the production of bobwhites. Others, although conventional farmers, still want to produce a maximum number of birds. Such landowners want and have asked for help in developing plans for the establishment and maintenance of the maximum production of quail. To render this assistance, we had to develop new methods to increase quail by land management.

In his study of quail in the Southeast, Stoddard (1931) observed that, to attract quail, an area must contain a plentiful supply of food close to good protective cover. The minimum size of a headquarters cover area was determined by Bushong (1959) to be approximately 450 square feet. It was the opinion of Robinson (1957) that the covey headquarters should be 15 yards square or 2,025 square feet. Robinson (op.cit.) found that cover must be such that incident light at the birds' level will be reduced to less than 1,000 foot-candles at midday.

Quail numbers have declined because of land-use changes, and their number per 100 acres is usually lower than when the land was more open with many small fields and fence rows. Woods also produce some quail, but they are very difficult to hunt on such lands. It was found by Speake (1967) in Alabama that unburned woodland produced only 11 birds per 100 acres. With controlled burning and about 10 acres of *Lespedeza bicolor*, an average of 50 birds per 100 acres was produced.

Our review of the literature and field experience suggested that providing food that is acceptable as to quality, quanity, variety, and seasonal distribution near to acceptable cover may be the way to increase bobwhite numbers in the Southeast today. Our objective, therefore, was to find ways of providing a headquarters area for bobwhite that could be easily established and maintained with farm machinery. Food, cover, and light shade would be available in one place for the birds. A second objective was to make hunting easy in the area.

A food and cover plot complex was designed and tested in the field. The plot has a center planting of shrub lespedeza (*Lespedeza bicolor*, *L. japonica,* or *L. thunbergi*). The plot is 70 by 70 feet and contains 700 to 800 plants. Rows are 36 to 42 inches apart. Plants are 18 to 24 inches apart in the row. On one side of the center planting is an area 70 by 10 feet in which five plants of pfitzer juniper (*Juniperus chinensis*) or eastern red cedar (*J. virginiana*) are planted. The plants are five feet from the shrub lespedeza and about five feet apart. If cedar is planted, it is kept at a height of about two feet. Such a planting gives the birds protection from light as well as from snow and ice.

Adjacent to this shrub planting, an area 80 by 70 feet is planted to a narow-leaf vetch, such as hairy vetch (*Vicia villosa*) or yellow vetch (*V. lutea*). A 70-by-90-foot area on the opposite side of the shrub lespedeza is also planted to narrow-leaf vetch. The two areas of vetch, the square of shrub lespedeza and the five cover plants complete the middle strip of the plot.

On one side of this middle strip, a 250-by-90-foot planting is made. browntop millet (*Panicum ramosum*), dove proso (*P. miliaceum*), or Chiwapa Japanese millet (*Echinochloa frumentacea*) can be used. On the opposite side of this middle strip, a similar 250-by-90-foot planting is made. Any of the following mixtures can be used: Kobe lepedeza (*L. striata*) and Korean lespedeza (*L. stipulacea*); corn (*Zea mays*) and Florida beggarweed (*Desmodium purpureum*); cowpeas (*Vigna sinensis*) and soybeans (*Glycine max* or *G. ussuriensis*). Soil types and rainfall help to determine which plants are adapted to a given site. The complete plot is 250-by-250-feet (Fig. 1).

In Georgia we have found that these food and cover plots improve quail hunting. This is especially true when a plot is located on each 20 to 25 acres of land. A 223-acre farm in Fayette County, Georgia, has 11 plots. There were 14 covies of quail in October for two successive years as a result of the plantings. In Gwinnett County, Georgia, a landowner established 27 plots on 539 acres. Four hundred of the acres were a mixed pine-hardwood stand. The second year he had 41 covies of quail in October. A neighbor observing the increased bobwhite production and the ease of hunting is now planting plots on his farm. He is establishing 15 plots on 360 acres. Another neighbor has established 16 plots on 425 acres, of which 225 acres are a pure pine stand. In Upson County, Georgia, a landowner established over 400 such plantings in 12,000 acres of woodland.

We recognize that some of these landowners have produced high populations of birds and that such populations may not occur in every case. We have done enough work with the plots, however, to know that we are producing more than 50 birds per 100 acres by the method described by Speake (op. cit.).

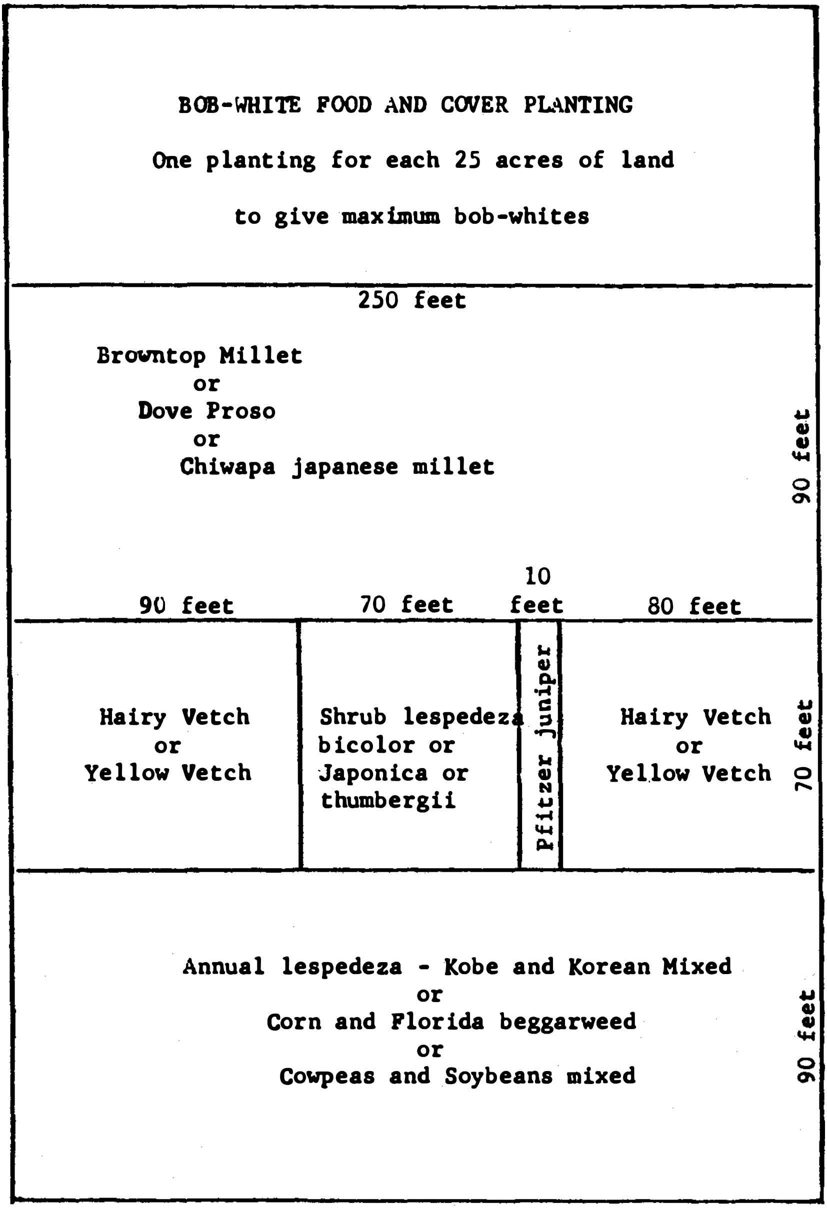


Figure I.—Bobwhite food and cover planting.

In summary, the planted plots as described here are a reliable method by which a landowner may increase the number of bobwhites on his land.

SUMMARY

The bobwhite is and has been one of the most important species of game for the Southeast.

Changes in land use over the past 20 years have been from small fields to large fields, from small pastures to large, well-kept pastures, and from small farm woodlots to extensive tree farms. This has not been conducive to the production and distribution of bobwhites.

To encourage production and distribution of the bobwhite in huntable numbers over these extensive areas requires supplemental food and cover plantings. Where landowners are willing to sacrifice as much as 5 percent of their cropland, pastureland, or woodland for the production of wildlife, an association of food and cover crops can be grown that will result in increased numbers and better distribution of bobwhites.

Field trials conducted during the past three years indicate that the production of bobwhites can be increased if this type of year-around food and cover plantings is provided.

LITERATURE CITED

Bushong, Clayton
1959. More quail—the easy way. Ind. Dept. of Conserv., Div. of Fish and Game P-R Project W-2-R-20. 13 pages.

Robinson, Thane S.
1957. The ecology of bob-white in South Central Kansas. Misc. Publ. No. 15, Univ. of Kansas, Mus. Nat. Hist. and State Biol. Serv. 84 pages.

Speake, Dan W.
1967. Development of good quail habitat in Piedmont pinewoods. Highlights of Agric. Res., Agric. Exp. Sta. Auburn Univ. 14(4):5.

Stoddard, Herbert L. Sr.
1931. The bobwhite quail, its habits, preservation, and increase. Charles Scribner's Sons, New York. 559 pages.

DISCUSSION

MR. VESALL: What does it cost to put in this system?

MR. SCHUMACHER: If you are going to put it in at custom prices and charge for everything, it is $76. If you are going to put it in yourself, it will cost you about $20. The rest of that is machinery. The Agricultural Conservation Program will pay $18 in relation to the establishment of one unit of these in Georgia.

MR. VESALL: Does it have application over a regionwide basis?

MR. SCHUMACHER: I think that it is a valuable tool to be used anywhere in the bobwhite range. I think it can be used anywhere. The only thing I didn't say is that this planting should be adjacent to woodland or a hedgerow or a travel lane that can be used by the quail. Don't put in one of these plots in the middle of a 500-acre field until you at least have a grass waterway or some travel lane where the birds can get to it. Once they get to it, they stay with it from then on.

MR. LEROY KORSCHGEN (Missouri): What is the source of the weed seed?

MR. SCHUMACHER: The weed seed mentioned is available through several seed companies in Georgia. That is about as far as I can go. The Pennington Seed Company is one of them. Pennington is statewide in their distribution.

WOODLAND HABITAT RESEARCH FOR NONGAME BIRDS

ROBERT G. HOOPER AND HEWLETTE S. CRAWFORD

Southeastern Forest Experiment Station, Forest Service, U.S. Department of Agriculture, Blacksburg, Virginia

Birds, small mammals, reptiles, and amphibians are an important part of the outdoor experience of nature watchers, picnickers, hikers, campers, and even casual Sunday drivers who like to stop along our byways to observe animals in their natural environment.

In 1968, bird watching and photography (nonconsumptive uses of wildlife) comprised 9,900,600 use days on the national forests, or almost one-quarter of the total estimated wildlife use. Despite this large and growing public interest, nongame wildlife does not receive the attention that wildlife managers extend to game species. Most managers appreciate the aesthetic importance of wildlife but have limited knowledge of habitat requirements of nongame species. Research is needed to define these requirements and provide a sound base for management decisions.

Our program for nongame wildlife is new; we have started with habitat research of woodland birds. The purpose of this paper is to describe bird habitat research, both active and proposed, at the Southeastern Forest Experiment Station.

THE PROGRAM

Nongame woodland birds are sensitive to habitat change. While their sensitivity may at times be unfortunate for a particular bird species, it is indeed fortunate for the reseacher faced with developing methods of managing birds. A bird's sensitivity to the habitat means there is something that can be measured and then manipulated to influence the occurrence of that particular bird.

The objective of our research program is to define habitat requirements which influence the occurrence of birds. When planning studies, we must consider (1) the categories of wooded areas to study, (2) the seasonal variation in bird behavior, and (3) the approaches to use in study design.

Categories of Wooded Areas:

Separating woodland into categories helps us to define our problem and conduct specific studies. Ecological and sociological conditions vary in the following types of woodlands.

1. *Intensively used wooded areas.* Parks, campgrounds, hiking trails, and self-guided nature trails are often heavily used. Can we

find ways to improve variety and numbers of birds in areas where they can be enjoyed by many?

2. *Urban wooded areas.* Our population is rapidly becoming urban. How can residential areas be developed or modified to support the optimum variety and numbers of birds which will help create a higher-quality human environment?

3. *Extensively used woodlands.* What are the effects of various land management practices, such as timber cutting, in the "big woods"? While these areas receive less human use than other areas, the maintenance of bird populations is important to maintain the proper ecological balance and a quality environment for less-intensive recreational pursuits.

Seasonal Variations:

Bird abundance and species composition and distribution, as well as the habitat, vary by season. Therefore, it is important to sample bird populations during seasons when the environment and these variables are relatively stable.

Breeding Season Studies

More published information is available for the breeding period than for any other season. This information gives us a basis for hypotheses formulation.

Lack (1933) expressed the idea that selection of breeding habitat by a bird was based on the recognition of features the bird did not necessarily require for survival; namely, structural aspects of the plant community. In other words, birds were programmed for particular patterns of foliage. Beecher (1942) had much the same contention. He also advanced the idea that a bird did not necessarily "adapt" to a so-called new habitat, but occurred there because its preconceived notion of "home" could be realized. Similar views are held by many European ecologists (Oelke, 1966).

Experimental evidence of a highly developed habitat preference in birds was provided by Stewart and Aldrich (1951). They censused a 40-acre spruce forest in Maine and then removed nearly all territorial males by shooting. Within a few days the area supported a population almost identical to the original. More important, the various species were occupying the territories originally occupied. Hensley and Cope (1951) continued the study and obtained similar results.

One of the first measurements of the habitat of a bird was made by Breckenridge in 1956. He concluded that the "percentage of openness" between the bottom of the overstory canopy and the next lower vegetation determined the occurrence of the least flycatcher (*Empidonax minimus*).

MacArthur, MacArthur, and Preer (1962) thought that each bird species was responding to a particular foliage profile determined by the vertical distribution of vegetation. The proportion of vegetation in three layers—0-2 feet, 2-15 feet, and greater than 15 feet—was measured for 100-foot-square plots. The plot most used by each bird species determined its preferred profile. The next step was to measure profiles for an uncensused habitat and to predict what species would be expected; their predictions were fairly accurate. Crowell (1963) used the same method to explain the success or failure of introduced species to colonize Bermuda.

One weakness of a vegetation-distribution method of determining habitat preference is that it does not consider density. MacArthur (1964) found that variations in bird occurrences among habitats were due to the density of vegetation as well as distribution. His findings seem logical. For example, if 3 layers of vegetation are recognized, and 10 density levels of foliage can be adequately measured in each layer, then potential combinations of foliage density-distribution equal 1,000. It is not likely that birds are stereotyped to the point they select only one combination, but rather occupy a range of related combinations.

Bird species commonly found together in a wooded area would not necessarily have similar requirements for combinations of vegetation density and distribution. Bond (1957) demonstrated a continuum in the distribution of birds that was related to a forest continuum. Distributions of 25 out of 27 bird species investigated were related to the forest continuum, and abundance of each species peaked at a different point along the forest continuum. Although he made few measurements of habitat structure, Bond found that canopy development and understory varied with the continuum. Thus, Bond was probably indirectly measuring the structural requirements (foliage density-distribution combinations) of birds. His findings suggest that several species of birds can occur in the same habitat but not be responding to the same stimuli.

Sturman (1968) measured the breeding habits of the chestnut-backed chickadee (*Parus rufescens*) and the black-capped chickadee (*Parus atricapillus*). He showed that these hole-nesting species were influenced by more than the presence of suitable nesting cavities. Sturman tested several variables by step-wise multiple regression, and found the average height of the upper story conifers and the percentage of the upper story volume in conifer accounted for more than 90 percent of the variation in the abundance of the chestnut-backed chickadee. Likewise, more than 90 percent of the variation in abundance of the black-capped chickadee was accounted for by the total volume of deciduous vegetation.

Based on these findings, the following working hypothesis is in order: the selection of habitat by breeding woodland birds is determined by habitat structure more than any other single factor. Of course, *a priori* conditions, such as climate, may exclude a bird from an otherwise suitable habitat. But at least in the case of climate, interactions exist that relate to habitat structure and make it difficult to separate the causal factor. In fact, birds could conceivably be using structure to assure themselves of the proper micro-climatic conditions for successful nesting.

To test our hypothesis, we are (1) planning studies to find the extent of breeding habitat selectivity for a variety of species, and (2) developing field and statistical methods to measure bird breeding habitat on a large scale. To provide the land manager with immediately usable results, the methods must give absolute values and not indices. Also, the methods must be simple and easy to apply so the land manager can plan specific habitats for birds in intensive-use areas.

Post-breeding Period Studies

The post-breeding period of late summer has received little recognition, mainly because of the complex ecological and behavioral factors during the period. Few species are engaged in the same activity—some renest, some nest for the first time, some are busy raising a brood, some are undergoing the post-nuptial molt, and some begin migration. This neglect in research is unfortunate because the period is also a peak human recreation period. The studies by Williams (1936), Hagar (1960), and Hooper and McGinnes (unpub. ms.) pertain to this period but throw little light on possible bird-habitat relationships. Consequently, we plan to direct more attention to this period, especially on intensively used woodlands. To collect the information needed for formulating hypotheses, our breeding period studies will be extended through late summer; however, the two periods will be analyzed separately.

Winter Period Studies

Winter is probably the longest period of relative stability in bird activity in temperate North America. Several hundred censuses of winter bird populations have been published in Audubon Field Notes since 1948. These were analyzed by Webster (1966), who concluded that winter bird density was dependent upon the number of species. This parallels Udvardy's (1957) hypothesis for the breeding period: "that bird density in temperate forests and woodlands is dependent upon the number of niches and the number of species at hand to settle there." Webster's analysis also suggested that different limiting factors affected winter bird populations north and south of latitude

38°N. This latitude corresponds to the southern limit of long-lasting snow cover. We are planning work to determine the effect of habitat variety, in different climatic provinces, on bird distribution and abundance in the winter period.

Research Approaches:

There are two major research approaches to solving habitat problems. Land-use impact studies, an applied approach, have been made by several workers (Dambach, 1944; Robbins, 1949; Warbach, 1958; Hagar, 1960). We used this approach to determine the effect of clearcutting—the regeneration stage of even-aged timber management—on bird populations (Hooper and McGinnes, unpub. ms.). The study showed that narrow clearcut areas had more birds during the breeding and late summer periods than did uncut forest stands, but had fewer birds during winter. The increase resulted from the attraction of "non-forest" species and the continued use of cut areas by "forest" species. About 40 percent of the breeding population was forest species, which increased to about 60 percent during late summer. The effects of different sizes and shapes of cuts on bird populations are still unknown. We have also studied the effects of wildlife clearings on bird communities. The results are preliminary and will be supplemented by further study.

Habitat analysis, a more basic approach, is an attempt to relate the occurrence of bird species to variables of the environment. A study conducted on breeding birds will illustrate. From preliminary work, we thought the difference in bird densities in forest stands was related to understory density. Several workers (Dambach, 1944; Preston and Norris, 1947; Odum, 1950) have pointed out the likely importance of understory. To further test the idea, we conducted a study to determine the relationship of understory density to breeding bird density. In eight recreation areas we measured the understory by the line-intercept method (Hooper and Kight, unpub. ms.) and determined the bird density by the territorial male method (Williams, 1936). A correlation of .88 (significant at the 95 percent confidence level) was found. Thus, about three-fourths of the variation found in the bird populations studied was accounted for by a single variable—understory density.

The advantage of land-use impact studies is that they are readily applicable to a management situation. A disadvantage is their failure to explain "why," and often the results cannot be extrapolated to a different environmental situation. Habitat analyses seem to be the most fruitful path to take in the future. Many problems, however, can be approached through land-use impact studies.

DISCUSSION

We predict that further study will reveal some interesting ecological relationships that have direct implications to the management of birds. This is not to say that a great deal is not already known about birds. But much of the information is qualitative, while land management is becoming more quantitative; thus, we should quantify the habitat requirements of birds. When biologists make quantitative information available, land managers should be able to tailor a residential area, campground, city park, or even extensive woodlands to the specifications of a given bird or perhaps optimize the population of an ecologically similar group of birds without conflict with the major human actvity.

SUMMARY

Little work has been done to determine the effect of habitat modification upon nongame species of wildlife. This paper illustrates two approaches to habitat research of nongame bird species presently being conducted by the Southeastern Forest Experiment Station, and describes our plan of work for the future.

Current needs point to increased bird-habitat research. With quantitative data, habitats for specific birds can be duplicated in park and urban environments.

LITERATURE CITED

Beecher, W. J.
1942. Nesting birds and the vegetative substrate. Chicago Ornith. Soc., Chicago Mus. Nat. History. 69 p.

Bond, R. R.
1957. Ecological distribution of the breeding birds in the upland forest of southern Wisconsin. Ecol. Monogr. 27:351-384.

Breckenridge, W. J.
1956. Measurements of the habitat-niche of the least flycatcher. Wilson Bull. 68: 47-51.

Crowell, K. L.
1963 . On determinants of insular faunas. Amer. Nat. 97:194-196.

Dambach, D. A.
1944. A ten-year ecological study of adjoining grazed and ungrazed woodlands in northeastern Ohio. Ecol. Monogr. 14:225-270.

Hagar, D. C.
1960. The interrelationships of logging, birds, and timber regeneration in the Douglas-fir region of northwestern California. Ecology 41:116-125.

Hensley, M. M. and J. B. Cope
1951. Further data on removal and repopulation of the breeding birds in a spruce-fir forest community. Auk 68:483-489.

Hooper, R. G. and J. Kight
The association of understory vegetation in developed recreation areas to breeding bird density. (Unpublished manuscript on file at Southeast. Forest Exp. Sta., Blacksburg, Va.)

———— and B. S. McGinnes
The initial effect of clearcutting on bird population in southwest Virginia. (Unpub. Ms. on file at Southeast. Forest Exp. Sta., Blacksburg, Va.).

Lack, D.
1933. Habitat selection in birds with special reference to the effects of the afforestation on the Breckland avifauna. J. Animal Ecol. 2:239-262.

MacArthur, R. H.
1964. Environmental factors affecting bird species diversity. Amer. Nat. 98:387-397.

————; J. W. MacArthur; and J. Preer
1962. On bird species diversity II. Prediction of birds census from habitat measurements. Amer. Nat. 96:167-174.

Odum, E. P.
1950. Bird populations of the Highlands (N.C.) Plateau in relation to plant succession and avian invasion. Ecology 31:587-605.
Oelke, H.
1966. Thirty-five years of breeding-bird census work in Europe. Aud. Field Notes 20:635-642.
Preston, F. W. and R. T. Norris
1947. Nesting heights of breeding birds. Ecology 28:241-273.
Robbins, C. S.
1949. Thirteenth breeding-bird census. Mature and lumbered oak-maple ridge. Aud. Field Notes 3:259-261.
Stewart, R. E. and J. W. Aldrich
1951. Removal and repopulation of breeding birds in a spruce-fir forest community. Auk 68:271-482.
Sturman, W. A.
1968. Description and analysis of breeding habitats of the chickadees, *Parus atricapillus* and *P. rufescens*. Ecology 49:418-431.
Udvardy, M. D. F.
1957. An evaluation of quantitative studies in birds. Cold Spring Harbor Symposia on Quantitative Biology 22:301-311.
Warbach, O.
1958. Bird populations in relation to changes in land use. J. Wildlife Manage. 22:23-28.
Webster, J. D.
1966. An analysis of winter bird population studies. Wilson Bull. 78:456-461.
Williams, A. B.
1936. The composition and dynamics of a beech-maple climax community. Ecol. Monogr. 6:318-408.

NATIONAL STATUS AND MANAGEMENT OF THE GREATER PRAIRIE CHICKEN

DONALD M. CHRISTISEN
Missouri Department of Conservation, Columbia

It was sixteen years ago, here in Washington, following the 18th North American Wildlife Conference, that National Wildlife Week was dedicated to the cause of the prairie chicken. It's time for a homecoming to count our blessings and our problems. Only in December of 1952, just preceding the conference, had the National Committee on Prairie Chicken been formed with the sponsorship of the National Wildlife Federation. Functions of the committee were twofold: (1) To call to the attention of the public and of responsible officials of state and federal government, the plight of the species; and (2) by general and specific recommendations to point a course or program for conserving and managing this valuable wildlife resource (Griswold, 1953).

In brief, this committee of 15 outstanding leaders in wildlife conservation recommended the following measures:

(1) Preservation of the bird as a living museum species in those states where remnant flocks and foreseeable land-use patterns offer no hope for hunting.
(2) Restoration and management as a game bird in states having a greater potential.
(3) More funds to be devoted by state game departments to prairie chicken research and acquisition of land.

(4) Legislation to make available to the states for wildlife purposes an unappropriated balance in the Federal Treasury . . . which accrued . . . under the Pittman-Robertson Act.
(5) Better coordination of research activities undertaken by the various states.
(6) Coordination of pinnated grouse and sharptail grouse research and management . . . where the two species overlap in range.
(7) Establishment of a grasslands national monument.
(8) Greater recognition of and attention to wildlife values by land-use agencies of Federal and State governments.
(9) Educational and publicity campaigns stressing the rarity and value of the prairie chicken and its habitat requirements.

Today we look back on accomplishments, scrutinize our shortcomings, study the current status of the greater prairie chicken [*Tympanuchus cupido pinnatus* (Brewster)], and try to see into the future.

Most of the information presented herein was obtained by letter and questionnaire from conservation departments of those states within the present occupied range. A summary of the major topics of information is presented in Tables 1 and 2. I am grateful to the dedicated conservationists[1] who patiently answered all of the questions and made this report possible.

Of the thirteen states contacted, one state (Iowa), reported no birds and one (Indiana), that the population was on the verge of extinction. Three other states (Michigan, Illinois, and Wisconsin), have populations of 1,000 or less birds, and only four states permitted hunting in 1967.

The present range of the prairie chicken can be divided roughly into two major components: Those states of the eastern tall-grass prairies and those states a part of the Great Plains region. The western states, with two exceptions, have larger chicken populations and are more concerned with hunting. Likewise, the character of the vegetation and land-use differs. The eastern tall-grass prairies are now intensively farmed and the drier western segment in mixed grass prairies is ranch country (Figure 1).

Originally there were about ten states in the eastern or tall-grass prairie range which supported greater prairie chickens in sizeable populations. Iowa, Ohio, Kentucky, and Arkansas no longer have

[1]M. E. Stempel, Iowa Conservation Commission; William E. Ginn, Indiana Department of Natural Resources; G. A. Ammann, Michigan Department of Natural Resources; Ronald L. Westemeier, Illinois Natural History Survey; F. N. Hamerstrom, Jr., Wisconsin Department of Natural Resources; Paul E. Bremer, Minnesota Department of Conservation; Karl F. Jacobs, Oklahoma Department of Wildlife Conservation; Gerald J. Horak, Kansas Forestry Fish and Game Commission; Robert Wood, Nebraska Game and Parks Commission; Warren Jackson, South Dakota Department of Game Fish and Parks; Gerald D. Kobriger, North Dakota Game and Fish Department; Donald M. Hoffman, Colorado Department of Natural Resources.

TABLE 1. EASTERN TALL-GRASS PRAIRIE RANGE OF THE GREATER PRAIRIE CHICKEN

	Indiana	Michigan	Illinois	Wisconsin	Minnesota	Missouri
Current population[1]	10	200	300	1,000	5,000	10,000
Last hunted	1936	1953	1932	1955	1942	1906
Population trend						
past five years	static	down	down	static	down	up
past ten years	down	down	down	down	down	up
Current research	no	no	yes	yes	no	no
Acres purchased for greater prairie chickens	640	436	847	10,000	10,000[2]	1,765
Land investment for greater prairie chickens						
by departments	$7,200	$12,795	none	$19,000	none	$133,000
by others	$2,400	none	$305,325	$501,500	none	none
More land needed for greater prairie chickens						
for hunting	no	no	no	no	no	no
for preservation	yes	yes	yes	yes	yes	yes
Research information sufficient for management	?	no	no	yes	no	yes

[1] Most liberal estimates used.
[2] Wetlands including some prairie chicken habitat.

TABLE 2. GREAT PLAINS RANGE OF THE GREATER PRAIRIE CHICKEN

	Oklahoma	Kansas	Nebraska	South Dakota	North Dakota	Colorado
Current population[1]	130,000	750,000	100,000	80,000	1,800	7,600[2]
Season	open	open	open	open	1945	none
Harvest[3]	14,000	46,000	15,000	10,000	—	—
Population trend						
past five years	up	static	static	down	down	?
past ten years	up	static	up	down	down	down
Current research	no	yes	no	yes	no	no
Acres purchased for greater prairie chickens	none	none	none	none	160	none
Land investment for greater prairie chickens						
by departments	none	none	none	none	$6,400	none
by others	none	none	none	none	$ 700	none
More land needed for greater prairie chickens						
for hunting	yes	no	no	yes	no	no
for preservation	no	no	no	yes	yes	yes
Research information sufficient for management	yes	no	no	no	no	no

[1] Most liberal estimates used.
[2] Evans (1963).
[3] Harvest for 1967.

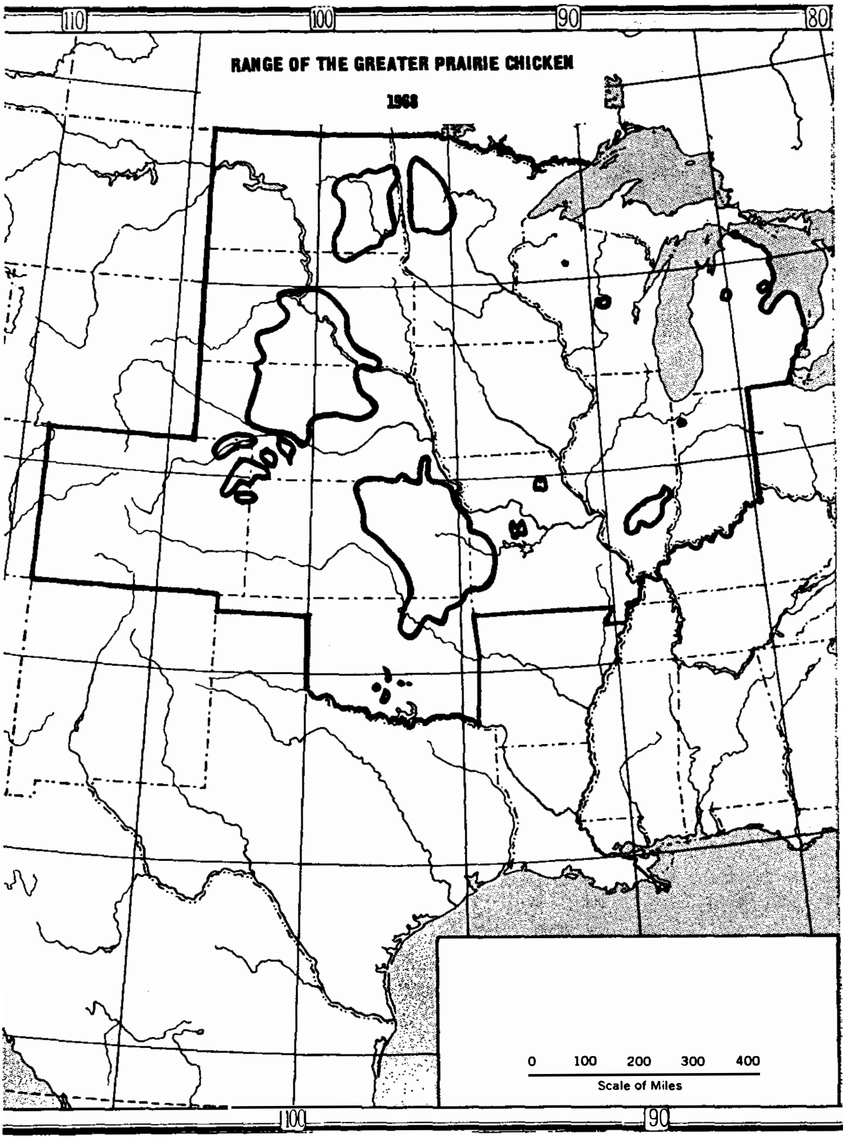


Figure I.—Range of the Greater Prairie Chicken.

birds. Only five states have enough breeding stock to maintain at least a flock or more of chickens as museum species. Together, Michigan, Illinois, Wisconsin, Minnesota, and Missouri have about 16,500 birds according to the most liberal estimates supplied by respondents. Birds have not been hunted legally in any of these states for at least 14 years and in one for 62 years. Population trends in the past five years for these six eastern states, have been down in three, static in two, and up in one state. Over the past ten years, the trend has been down in five states and up in one.

The severity of the decline and fall of the greater prairie chicken empire can be related for each of these states. All have the same plot with variations. As an example, the Minnesota Conservation Department believed hunters took 416,900 pinnated grouse in 1925 (Griswold, 1953). This was almost five times as many chickens as were bagged in the four states with open seasons in 1967. Minnesota hunters bagged approximately 58,000 chickens in 1942. Although this was the last open season, the decline has continued with an estimated 5,000 prairie chickens remaining.

This may be the year of extirpation for prairie chickens in another great grouse state. In 1912 at least 100,000 birds populated the prairies of Indiana; in 1941 about 1,000 birds remained (Barnes, 1946). From riches to rags in 29 years! The chicken was legally hunted as late as 1936; by 1959 the population shrank to 87 males counted on booming grounds. Last year only five male pinnated grouse were located in all of Indiana!

Missouri prairie chicken populations have suffered too, despite a closed season since 1906. Hundreds of thousands of pinnated grouse once populated the prairies of the Show-Me state. This tremendous population was under 15,000 birds by the early 1940's. The loss of some 1600 square miles of habitat since the 1950's has reduced the population even further. Less than 10,000 birds populate about 900 square miles of Missouri's range today.

The the west, where the tall-grass prairies and the mixed-grass prairies blend, the pioneer vista of space and grass lingers. Prairie chickens occur in all six states comprising this Great Plains range, and in four states the population is large enough to support hunting seasons. Only Colorado and North Dakota have year-round closed seasons. The most liberal estimates credited Oklahoma, Kansas, Nebraska, and South Dakota with a combined population of about 1,060,000 birds. Hunters in these four states bagged 85,000 prairie chickens in 1967. The prairie chicken population for all six western states was estimated to be in the magnitude of 769,400 to 1,069,400 birds. Population trends within the past five years have been down in two states, static in two, and up in one, with one state in question. Over the past ten years the trend has been down in three states, up in two and static in one state. In only one of the four states permitting hunting has the population trend been up for both periods (Oklahoma).

The greater prairie chicken moved into much of the Great Plains with the homesteader and sodbuster. The bird was adaptable enough to persist in marginal habitat wherever patches of farm food crops occurred in the extensive, semi-arid grassland. Even in the states where hunting is still permitted, super-abundance of chickens occurred in the tall grass prairies before the plows forced the birds farther west into the drier mixed grass prairies, of the present-day ranchlands.

Answers received concerning the primary limiting factor of prairie chicken abundance were in general agreement, particularly for the eastern states. Lack of permanent grass of sufficient quality and quantity to furnish protection for the birds was the basic factor. This resulted from many causes but primarily these: Conversion of grass to tilled crops, loss of open grasslands to trees and shrubs, and removal of grass cover by grazing and haying.

In the western portion of the range, loss of grass cover was still a primary limiting factor but other factors tended to amplify the problem even where grass was present. Overgrazing as well as extensive burning of prairies became more prominent factors in habitat deterioration. Lack of winter food was considered a limiting factor in some states, such as Colorado and Nebraska, even though grass cover was sufficient. Oklahoma reported uninterrupted grassland *i.e.* too much grass—to be the primary limiting factor. Directly or indirectly the fortunes of this bird are tied up with grass.

In pre-settlement times, most of Iowa, 60 percent of Illinois, and 40 percent of Missouri were tall-grass prairies. Today these native prairies are gone except for a few remnants and preserves. Only Missouri has some 100,000 acres remaining. Even the tall-grass prairies on the eastern side of the Great Plains have suffered inroads of plowing and overgrazing as elsewhere. The chicken has had to survive not only with less grass but in most instances with tame grasses. Podoll (1961), in defining the Great Plains prairie chicken range, points out that in the mixed grass prairies, the tall grasses, particularly big bluestem, appear to be of major significance to chickens. He indicated that, under present grazing practices, it is unlikely big bluestem can persist east of the 16- or 18-inch precipitation line. Chicken populations occurring west of the 18-inch precipitation line are confined to zones or localities with some big bluestem.

Podoll associated the major decline of the greater prairie chicken with the drouth period of the 1930's which brought replacement of tall grass prairie species with drouth-tolerant short-grass species.

Moreover, not only is it a matter of quality within the tall-grass prairie region, but one of quantity in relation to farm crops. Hamerstrom *et al.* (1957) in Wisconsin, Baker (1953) in Kansas, and Schwartz (1945) in Missouri, all emphasized the importance of proportion. There was general agreement that at least one-third of the non-forested habitat should be in permanent grass. In Missouri, populations persist now in areas of 25 to 30 percent grass.

Recognition of the problem is only the first step toward restoration, preservation, and management of the greater prairie chicken. If recognition has been difficult in some instances, then funding of an effective program to aid the prairie chicken has been equally difficult, and certainly more frustrating by the knowledge of what must be done. In reviewing the responses to questions concerning research, management and acquisition of lands for prairie chickens, the depth of interest on the part of the states was evident.

Hopefully, wildlife conservation relies on research for answers to complex problems. Apparently the problems are few or research isn't needed for the answers to the difficulties of the prairie chicken. Excluding inventories, surveys, and routine compilations of pinnated grouse harvest information, research is being conducted in only four states, two in each portion of the range. No research is planned in those states not having research underway.

Of course, acquisition of land specifically for prairie chickens plays a major role in determining whether there shall be research and management. Although not a pre-requisite for either, land acquisition has become essential in states striving to preserve the prairie chicken. Six states have acquired lands specifically for the chickens; another state (Minnesota), has included significant acreages of chicken habitat with a wetlands program. All, with possibly one exception, plan to continue acquisition of lands for prairie chickens whenever possible. Five states have not acquired any lands, but one plans to acquire lands for prairie chickens. The six states have acquired 13,848 acres and with the wetlands addition of another state, bring nearly 25,000 acres of prairie chicken habitat under protection. The investment in land by the seven states represents $988,320. Of this amount, only $178,395 represents funds expended by conservation departments; the bulk of the monies for acquisition came from private organizations concerned about the plight of the greater prairie chicken. As expected, the emphasis on acquisition of lands was most pronounced for states experiencing difficulty in maintaining chicken populations, mostly those in the East. All six states in this portion of the range acquired lands for prairie chickens, although one was tied into waterfowl land purchases. In the West, only one of six states (North Dakota) has acquired any land specifically for prairie chickens.

This leads us to the question of need. All six of the eastern prairie states and four of the six western states indicated more land for prairie chickens was needed. All of the eastern and two of the western states (Colorado and North Dakota) indicated land acquisition was a matter of preservation. One western state (Oklahoma) indicated it was a matter of both preservation and hunting, and one wanted the land for increasing hunting opportunities.

Management of lands for the greater prairie chicken amounts to 25,000 acres, slightly more than that acquired. Eight states, including all six in the East, have land management underway or planned for chickens. Seven states have implemented one or more specific practices. In conjunction with the management question, inquiry was directed as to the value of the recent Soil Bank Program. Responses from five eastern states and one western state indicated the Soil Bank Program had been beneficial for the prairie chicken and was of some benefit in parts of three other states. In relating management to research, it was interesting to note that only three states considered present research information sufficient for good prairie chicken management in their respective states, yet only four states are conducting research.

Concern for the greater prairie chicken is centered solely on preservation in four states, on preservation with the hope of limited hunting in three states, on both hunting and preservation in two states, and hunting only in two states. One indicated that if concern were present it would favor preservation.

In describing the outlook for the greater prairie chicken in the next twenty-five years, most adjectives used were pessimistic in tone: bleak, very poor, grim, dismal, etc. The respondents for only two states saw good years ahead, and one of these hedged at good for 5-10 years.

We wonder if the next few years will be as lenient on chickens as the past 16 years. Despite difficult times, the estimated total population has not shown a decline, but an increase. Apparently productivity of prairie chickens in the big four states, particularly Oklahoma, has more than offset losses of range and birds in the eastern states. In 1952 five states, including two eastern states, had sufficient birds for hunting; in 1967 there were four states with open seasons, of which three were carryovers from 1952. The eastern states of Michigan and Wisconsin had fallen from the list of states permitting hunting. On the positive side, Oklahoma became a chicken hunting state in the interim.

After reviewing this information and looking back to recommendations of the National Committee on Prairie Chicken, we have reason to question: Is it a matter of too little and too late? Have we gone far enough, fast enough? Is the difference between the haves and the have nots as great as one might believe? Is the sum of $178,395 a meaningful gesture by state conservation departments toward the welfare of the prairie chicken? Must conservation programs for a native bird be dependent on whether it is hunted or not? And why not state-owned lands for the prairie chicken where it is hunted? Are federal public lands suitable for chickens being utilized at their potential?

One recommendation by the committee, establishment of a grasslands national monument or park, has not materialized. Although more symbolic, perhaps, than practical, it would have immense value from an educational and publicity viewpoint in rallying conservationist interest nationwide to the cause of the prairie chicken.

It is heartening to learn that all twelve states have, or had, some form of research, management, and/or land acquisition program in action or planned for the benefit of the prairie chicken. At least three states—Wisconsin, Illinois and Missouri—have private organizations functioning to acquire lands for the benefit of this bird.

Mention should be made of three states, not only for their accomplishments but because their activities illustrate the variety of approaches and situations regarding the greater prairie chicken problem. Wisconsin has virtually carved a prairie chicken range out of marshland habitat. Through the combined efforts of the department and private conservation organizations in Wisconsin, $520,000 has been raised in the course of acquiring 10,000 acres specifically for the prairie chicken. In the creation and management of this habitat, Wisconsin appears to have met the challenge of prairie chicken survival.

Missouri, the only eastern state with an appreciable acreage of native prairie remaining, has made an effort to preserve some of this habitat. Its conservation department topped all others in expenditure of funds for land acquisition specifically for prairie chickens, with a total of $133,000. This represents the cost of two areas, totaling 1,765 acres of mostly tall-grass prairie. Establishment and management of these areas has stabilized prairie chicken populations in their respective localities and provided a place for the public to view the birds in a natural setting.

Oklahoma, with good management, including a transplanting program, and riding an upward tide of chicken production, has rejoined the states having open seasons with a series of recent successes. The department plans to purchase 3,500 acres in small parcels interspersed throughout extensive private grasslands as public hunting areas. Outlook is most promising as extensive marginal timber and agricultural lands are being converted to grass.

Probably the most significant force in unifying and stimulating ideas for the good of the prairie chicken has been the opportunity to exchange information and ideas between states. Following the preliminary work of the National Committee, there evolved, with the Committee's blessing, an informal organization of technicians concerned with chicken problems. The Prairie Grouse Technical Council, sponsored by the National Wildlife Federation, held its first meeting at Grand Island, Nebraska in 1957. There have been six more council meetings in as many different grouse states since then. Each meeting has consisted of a day or more of informal presentations concerning prairie chickens and sharp-tailed grouse, with a day devoted to a field trip in the grouse range of the host state. Membership is unrestricted, but the nature of the problems attract research and management people.

The best asset is the bird itself. The prairie chicken is a natural in commanding the attention of hunting and non-hunting public alike because it is both game and colorful. This double facet advantage should not be underestimated by administrators. Conservation departments intent on improving their image with the non-hunting public have an opportunity to recruit friends for their entire conservation program by improving the welfare of the prairie chicken.

There does seem to be a finer sense of resource management developing. Although some struggles have been lost and a few are in doubt, hopefully, populations of the greater prairie chickens can be maintained in most of these states, at least for public appreciation if not always in numbers sufficient for hunting.

LITERATURE CITED

Baker, Maurice F.
1953. Prairie chickens of Kansas. Univ. of Kansas State Biological Survey, Misc. Pub. No. 5, 68 pp.

Barnes, William B.
1946. What about the prairie chicken in Indiana? Outdoor Indiana, rep. March-April, 2 pp.

Evans, K.
1963. Inventory of greater prairie chickens. Colorado Game, Fish and Parks department, Federal Aid Quarterly.

Griswold, Dwight
1953. National Committee on the Prairie Chicken issues first report. rep. Congressional Record, Proc. and Debates of 83rd. Congress, First Session, March 13, 2 pp.

Hamerstrom, Jr., F. N., Oswald E. Mattson and Frances Hamerstrom
1957. A guide to prairie chicken management. Wisconsin Conserv. Dept. Tech. Wildlife Bul. No. 15, 128 pp.

Podoll, Erling B.
1961. Characteristics of the Great Plains prairie chicken range. Mimeo. 22 pp.

Schwartz, Charles W.
1945. The ecology of the prairie chicken in Missouri. Univ. of Missouri, Studies 20(1). 99 pp.

DISCUSSION

MR. HUGH CRAWFORD (Virginia): You mentioned the increase in the chicken population occurring in Oklahoma. I think in Oklahoma there probably has been a million or more acres of woodland converted to grassland. As you know, the same practice is going on in Missouri and Arkansas.

What are your thoughts along the line of the possibility of this practice being beneficial to the chicken population, and what other factors do you think might be taken into consideration with increasing chicken population on these newly created areas?

MR. CHRISTISEN: We should not overlook the possibility of creating new range. for the prairie chicken. This would be particularly true, of course, for those states that have marginal timberland and lands that could be converted to grasslands. I am not too well acquainted with the possibilities here but it certainly would be something to consider.

MR. VESALL: Would you like to comment on the value of land retirement programs? We found, in Minnesota, that this gave a lot more grassland acreage, and it helped the prairie chicken.

MR. CHRISTISEN: This seems to vary from state to state. In general, the eastern states seem to profit more from land retirement or conversion than where we have grasslands. I am thinking particularly of such things as the soil bank program and where, in answer to a questionnaire, respondents in the eastern states indicated they felt it benefited the prairie chicken. As we move into the western country, apparently this was not particularly helpful to the prairie chicken.

MR. VESALL: Did some of the states comment on the need for a strong I. and E. program?

MR. CHRISTISEN: We did not have a question on that and therefore I cannot comment.

HIGH NEST DENSITY AND HATCHING SUCCESS OF DUCKS ON SOUTH DAKOTA CAP LAND

Harold F. Duebbert
Bureau of Sport Fisheries and Wildlife, Jamestown, North Dakota

Agricultural land retirement programs have provided thousands of acres of prime wildlife habitat in the United States in recent years. Three years ago at this conference Jaenke (1966) described opportunities for wildlife management under the Cropland Adjustment Program (CAP) authorized by the Food and Agriculture Act of 1965. The goal of this U. S. Department of Agriculture program is to shift approximately 40 million acres of land from surplus crop production to conserving uses. Grasses and legumes are to be planted on such idled lands under 5- or 10-year contracts.

This paper presents an outstanding example of wildlife benefits found on one tract of cropland retired under the CAP. An unusually high density of duck nests and excellent hatching success was documented in 1968 on 125 acres of land retired in 1966 in Edmunds County, South Dakota. Duck nest data for the CAP land are presented along with information on breeding populations and brood production.

Utilization of retired cropland for reproduction by ground-nesting birds has not been well documented except for ring-necked pheasants (*Phasianus colchicus*). In an Illinois study of the Federal Feed Grain Program, Joselyn and Warnock (1964) reported that unharvested hayfields, although comprising only 5.6 percent and 2.4 percent of the land area during 1962 and 1963, respectively, contained 52.4 percent and 28.6 percent of all successful pheasant nests in these 2 years. Gates and Ostrom (1966) reported on the high value of unharvested hayfields in the Federal Feed Grain Program to pheasants in Wisconsin. On Program lands within their study area, 59 percent of the nests hatched, compared to 26 percent in all other cover types. Predation was comparatively low in this retired agricultural land, affecting only 12 percent of the nests in unharvested hay. The authors suggested that pheasant production could be enhanced if cover quantity and quality were improved to attract nesting hens from less productive cover types.

One of the few studies documenting the important influence of the Soil Bank Program on pheasant populations in the north-central states was reported by Schrader (1960). He concluded that "the increase of [pheasant] population between 1956 and 1958 [in Iowa, Minnesota, Nebraska, North Dakota and South Dakota] resulted largely from the above-average success of nesting and that there was a higher rate of increase in those counties with more than 5 percent of the cropland idle." From 1956 to 1958, pheasant population increases in the above states ranged from 17 percent in North Dakota to 96 percent in South Dakota on the basis of roadside counts.

A study conducted in west-central Minnesota from 1957 to 1960 (Benson; *In* Moyle, 1964) provided information on the influence of newly retired Soil Bank lands on duck production. Twenty-two of 58 nests (38 percent) found were located in Soil Bank lands, more than in any other cover type. Highest hatching success (41 percent) occurred in Soil Bank land. It was concluded that nesting ducks could produce one-third more broods in cover similar to that found on retired crop lands than in other vegetative types studied.

STUDY AREA

The present study was conducted near the town of Hosmer, located in Edmunds County in north-central South Dakota (Figure 1). Ground and stagnation moraines are the predominant land forms in this glaciated prairie region. The gently rolling terrain in the vicinity of Hosmer contains 40-50 natural wetlands per square mile. Wetlands are classified as Types 1, 3, and 4 (Shaw and Fredine, 1956) and range from less than 0.1 acre to 20 acres in size. Water depth in the various basins fluctuates from 0 to about 4 feet, depending on topographic variations and seasonal and annual precipitation patterns. It is not unusual for most wetlands in the vicinity to be dry by early fall. The wetlands are characterized by a freshwater ecology, and most of them are subject to frequent disturbance by grazing, haying, or tillage. Snow melt and rainfall during 1968 supplied a favorable water budget for breeding pair occupancy. Adequate water levels were maintained for brood-rearing.

The land-use pattern in this locality consists of small-grain farming and tame hay production on about two-thirds of the area, with cattle grazing on native grasslands and miscellaneous uses on the remainder. Soils are fertile, deep, friable loams. The high incidence of post-harvest tillage and heavily grazed pastures and the low occurrence of idle land create an overall aspect of intensive agricultural utilization. At the time ducks begin to nest, good-quality nesting cover is scarce.

METHODS

To obtain an index to the duck breeding population in the area, a 4-square-mile block, including the CAP field, was surveyed by the author and an assistant on May 22 (Figure 1). Pairs of ducks, lone males, lone females and male groups of three individuals or less were tallied as resident breeding birds. Each water area in the survey block was carefully searched. If the water surface was relatively open, the count was made from a distance without flushing the birds. If a wetland contained tall or dense vegetation, ducks were flushed by wading slowly through the pond. Duplicate counting was minimized

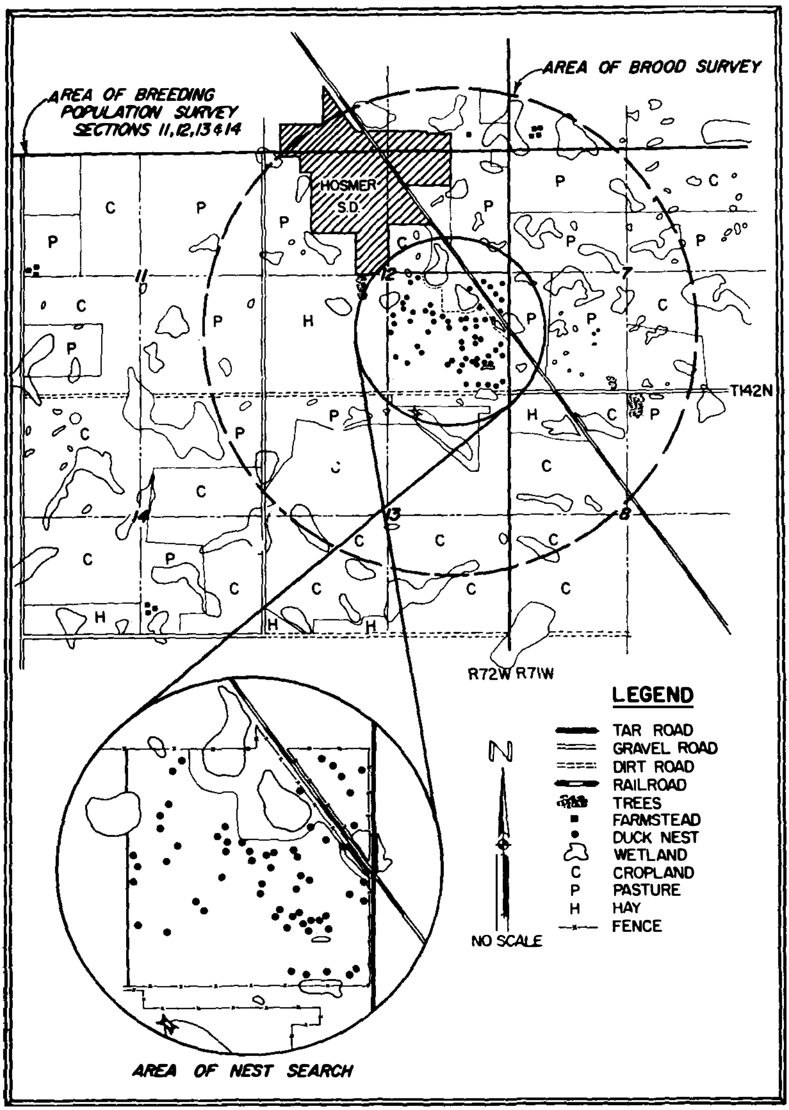


Figure 1.—Study Area.

in these instances by noting the ducks' flight patterns until they landed or left the area.

On June 4 the CAP acres were completely searched for nests by dragging a 115-foot-long steel cable-chain assembly between two vehicles (Higgins, Kirsch, and Ball, unpubl. ms.). The search was conducted between 8:00 a.m. and 8:15 p.m. Wetlands, grass wetland borders, railroad and road right-of-ways and fencerows located within the southeast quarter of section 12 were not included in the nest search. Nests located where hens were flushed were examined, and clutch size, stage of incubation (Weller, 1956) and other data were recorded on Unisort Analysis Cards. Nest locations were marked with tall, slender willows for rechecking of nests after the calculated hatching dates.

A walking "beat-out" census of broods was conducted by the author, an assistant and a Labrador retriever on July 26 within a circular area having a 1-mile radius based on the center of the CAP field (Figure 1). All wetlands were thoroughly searched by wading slowly throughout the emergent vegetation. Water depths were recorded for all wetlands during the late-May and late-July censuses. A record of vegetation occurring in the field was prepared on the basis of visual observations during visits. Height and density of vegetation were recorded photographically at several locations.

RESULTS

Breeding Population

The duck breeding population on the 4-square-mile block was about 200 pairs, or 50 pairs per square mile. Species composition of the observed breeding population is shown in Table 1. Breeding populations surveyed by me on nearby block and transect study areas in 1967 and 1968 were of similar species composition and density. Pairs and lone males appeared to be spaced uniformly throughout available habitat and not disproportionately near the area of high nest density.

TABLE 1. BREEDING DUCK POPULATION ON A 4-SQUARE-MILE BLOCK SURROUNDING CAP LAND—MAY 22, 1968

Species	Pairs Observed	
	Number	Percent
Mallard	17	9
Gadwall	52	26
Pintail	29	15
Green-winged teal	4	2
Blue-winged teal	47	24
American widgeon	8	4
Shoveler	30	15
Redhead	10	5
Total	197	100

Nesting

Sixty-one duck nests were found on the 125 acres (Figure 1), for a density of approximately one nest per 2 acres. Five nests were found during the breeding pair survey on May 22, 53 were found during the main search with the cable-chain drag on June 4, and three were found on July 8 while rechecking other nests. Nests of all species of upland nesting ducks resident in the area were found.

Species composition and success of nests are shown in Table 2. The calculated hatching success of 79 percent for the 58 nests of which fates are known includes 4 nests which were deserted because of our disturbance. Three nests could not be relocated and are not included. One nest of an American widgeon contained 10 eggs which were either infertile or contained embryos that died early. These eggs were collected after the hen sat for 35 days. Destruction of six of the seven nests broken up by predators was attributed to badgers (*Taxidea taxus*). A group of badger dens in the southwest portion of the field were used by a pair of adults and their young during May, June and July.

It was apparent that activity by other mammalian predators was unusually low in the CAP field. Very little mammal sign was observed in the field although tracks, scats, sight observations and car-killed animals verified the occurrence of red foxes (*Vulpes fulva*), striped skunks (*Mephitis mephitis*), spotted skunks (*Spilogale putorius*), raccoons (*Procyon lotor*) and badgers on neighboring lands. Apparently the CAP field was within part or all of the home range of these animals, but the height and density of vegetation there deterred regular travel. Other potential nest predators in the locality but not seen in the field included abundant populations of Richardson's ground squirrels (*Citellus richardsonii*) and thirteen-lined ground squirrels (*Citellus tridecemlineatus*) and a low population (1 pair per 6-8 square miles) of crows (*Corvus brachyrhynchos*).

The extremely high density of nests observed probably did not represent all those the field may have actually supported. Following

TABLE 2. SPECIES COMPOSITION AND SUCCESS OF DUCK NESTS IN CAP LAND, 1968.

Species	Nests Found		Nests Hatched	
	Number	Percent	Number	Percent
Mallard	23	40	19	83
Gadwall	10	17	9	90
Pintail	6	10	3	50
Green-winged teal	1	2	1	100
Blue-winged teal	13	22	10	77
American widgeon	2	3	1	50
Shoveler	3	5	3	100
Total	58	99	46	79

are the reasons for this belief. Hatching chronology data for the region based on back-dated broods and nests, indicate that 13 percent of the duck broods hatched prior to June 4. Kirsch, Higgins and Ball (*unpubl. ms.*) reported that only 79 percent of gadwalls and blue-winged teal known to be on nests flushed when the cable-chain drag passed over. Lastly, other nests could have been missed because hens were away for their daily rest period.

Most of the nests in the CAP field probably represented first nesting attempts for the individual hens. This belief is strengthened by the observed average clutch sizes (Table 3) and nesting chronology data (Table 4) in relation to published and unpublished waterfowl production data. The field was apparently used but little for late-season nesting. Few nests were found while walking through the field with a dog during late June and July to check nest fates.

Of 426 eggs observed in successful nests, 419 (98.3 percent) hatched. The seven eggs that were left showed no evidence of embryonic development. Thus, egg viability was very high in this cover type.

Broods

Table 5 presents data on broods observed on July 26 within a 1-mile circle centered on the CAP field. No marked hens were available for observation, but apparently many of the broods which hatched in the CAP field moved north and east for 0.25 to 2.0 miles. The area to the

TABLE 3. NUMBER OF EGGS IN INCUBATED DUCK NESTS ON CAP LAND.

Species	Nests	Eggs	Average per nest
Mallard	21	176	8.8
Gadwall	10	98	9.8
Pintail	3	23	7.7
Green-winged teal	1	8	8.0
Blue-winged teal	10	100	10.0
American widgeon	2	18	9.0
Shoveler	5	53	10.6
Total	52	476	9.1

TABLE 4. DATES WHEN DUCK NESTS WERE BEGUN ON CAP LAND IN 1968.

Species	Number initiated during week beginning								
	4/22	4/29	5/6	5/13	5/20	5/27	6/3	6/10	Total
Mallard	—	2	4	7	5	6	—	—	24
Gadwall	—	—	1	1	7	—	—	1	10
Pintail	1	—	2	—	1	2	—	—	6
Green-winged teal	—	—	—	—	—	—	—	1	1
Blue-winged teal	—	—	—	1	6	6	—	—	13
American widgeon	—	—	—	—	1	—	—	1	2
Shoveler	—	1	1	—	2	1	—	—	5
Total	1	3	8	8	22	15	—	3	61

TABLE 5. DUCK BROODS OBSERVED IN WETLANDS WITHIN ONE MILE RADIUS OF CAP FIELD, JULY 26, 1968. (APPROXIMATELY 3 SQUARE MILES)

Species	Broods Observed	
	Number	Percent
Mallard	6	10
Gadwall	17	30
Pintail	4	7
Green-winged teal	2	3
Blue-winged teal	21	37
American widgeon	1	2
Shoveler	5	9
Redhead	1	2
Total	57	100

north and east had many Type 3 and Type 4 wetlands which contained adequate water and abundant food for brood-rearing. Many broods were observed in this area during routine travel through it and on the intensive survey. Little brood-rearing habitat existed on the CAP field.

DISCUSSION

This record of high nesting success in relation to a known environment contains important guidelines for management of upland vegetation in duck production areas. It suggests that female ducks of many species prefer dense, idle herbaceous vegetation for nesting if it is available and that most nests located in such cover are successful. Waterfowl ecologists have recognized that wetland habitats are usually more biologically productive during the earlier stages of succession (Weller and Spatcher, 1965). Perhaps early successional stages of upland vegetation are an equally important factor in high duck production. Future research directed toward determination of the optimum stages of ecological succession for highest nest density and hatching success of individual waterfowl species would be of value.

Events leading to the establishment of high-quality nesting cover on this CAP land are pertinent to this discussion. The field was used for small grain production for many years prior to 1960, when it was placed under the Soil Bank Program. In 1965 the field was cultivated for 1 year and then placed under a 5-year CAP contract in 1966. Intermediate wheatgrass (*Agropyron intermedium*) was planted at the rate of 6 pounds per acre in 1966. Volunteer vegetation contributed greatly to the cover form prevalent in 1968. Sweet clover (*Melilotus officianalis* and *M. alba*) and alfalfa (*Medicago sativa*) were important components of the nesting cover, apparently growing from adventitious seed. The field contained many forb species including sow thistle (*Sonchus arvensis*), flixweed (*Descurainia sophia*), marsh elder (*Iva xanthifolia*), common sunflower (*Helianthus an-*

nuus), giant ragweed (*Ambrosia trifida*), absinth (*Artemesia absinthum* and others. These species are commonly present on cultivated land or disturbed sites in the area. In all, 59 species of native and introduced plants were identified in the field and on contiguous permanent sod areas.

The preference for sweet clover as nest cover was emphasized by the fact that about one-half of the mallard nests and one-fourth of all duck nests were located in this vegetation. Coarse forbs, intermediate wheatgrass and crested wheatgrass comprised the dominant vegetation around more than half of the other nests.

Fallen-over vegetation and an abundance of ground litter composed of dead grass and weed stalks from previous growing seasons formed conspicuous components of the nesting cover. The resulting tangle of dead vegetation was probably the most important single factor contributing to the high hatching success. Such litter is also the component most often lacking in potential duck nesting cover over much of the prairie region where intensive agricultural utlization prevails. This fallen-over vegetation and ground litter concealed nesting hens well from all directions, provided a strong deterrent to predatory mammal activity and provided ideal temperature and moisture regulation essential for high egg hatchability. Most nests were so perfectly concealed that hens were not visible to human vision at distances of 2 or 3 feet. Such cover minimized horizontal movement of scent by air currents as a factor in predators finding nests. While tall, dense vegetation was the gross aspect of the nesting cover, numerous small, relatively open zones within the field were present.

It is unusual to find 61 duck nests on 125 acres of land in the glaciated prairie region. While this high nest density provided a record of great interest, the 79 percent hatching success of the 58 known-fate nests was perhaps the most important finding. The significance of duck nesting data reported in this paper is emphasized by comparing them with nesting data from a 6-square-mile block of land located 4 miles south of the CAP field where the land is utilized for a diversified agricultural economy. On this study area only 22 of 72 (30 percent) upland duck nests under observation hatched in 1968. Of the 50 nests which failed on that study area, causative factors included: mammalian predation, 37 nests; avian predation, 1 nest; agricultural operations, 6 nests; and desertion due to observer interference, 6 nests. This area probably provided a fairly typical example of the reproductive fate of the ducks nesting in diversified farming areas of the glaciated prairie region. Many other studies in the north-central states and prairie Canada verify the low hatching success of duck nests during recent years (Moyle, 1964;

Evans and Wolfe, 1967; Gates, 1965; Keith, 1961). These studies have indicated hatching successes ranging from 11 to 34 percent of the nests observed. Failure of nests due to predation and agricultural operations is generally acknowledged to be the most important single factor lowering annual productivity rates of upland nesting waterfowl in the prairie region. Therefore, any manipulation of land use or vegetation which reduces the serious impact of these mortality factors may be expected to have a beneficial effect on duck production.

The relationship of mallard nests to distribution of the breeding population is of interest. Twenty-four mallard nests were found on the 125-acre CAP field, but only 17 pairs were observed on the 4-square-mile block surveyed. Mallard pairs comprised 9 percent of the duck breeding population on the block while 40 percent of all nests were of this species. This strongly suggests that some of the nesting mallard hens must have flown to the prime cover from relatively long distances, perhaps 3 to 5 miles. It also indicates that in areas having good duck breeding and brood rearing habitat, nest site selection can be influenced favorably by manipulation of land use patterns or vegetative growth forms. The percent composition of nests of other duck species approximated their abundance in the breeding population.

To place the above data in historical perspective, a statement made 70 years ago by Job (1898) after visiting a group of islands in Stump Lake near Lakota, North Dakota, is pertinent: "To find fifty sets of ducks' eggs in a day is by no means a common occurrence, even in Dakota."

MANAGEMENT IMPLICATIONS

The present status of North American duck populations is well known. Decreasing duck supply and increasing public demand seems to aptly describe the future for most waterfowl species. Waterfowl biologists and administrators are keenly aware that as quantity of duck production habitat decreases more birds will have to be produced on the remaining area if populations are to be maintained. Various methods of increasing waterfowl production have been integrated into operative management programs. However, additional improvement of habitat management techniques will be required.

It is apparent that all suitable federal and state lands devoted to waterfowl should be managed for maximum production in the future. Hochbaum and Bossenmaier (1965) estimated that only 2 percent of all waterfowl production occurs on such managed areas, however, and 98 percent on private land. Programs involving retirement of privately-owned agricultural lands often provide a much greater and better countrywide distribution of prime cover than can be accomplished on wildlife agency lands. For example, information provided by the ASCS office in Ipswich, South Dakota, indicated that there were 4,387 acres of land under the CAP in Edmunds County in 1967. The present study documented that at least 419 ducklings were produced on 125 acres (3.3 ducklings per acre). If all CAP lands in Edmunds County produced at this rate, the production of 15,000 ducks would have been a by-product of this agricultural program.

Future recreational demands on the waterfowl resource will necessitate the use of every technique available for increasing annual reproductive success. Agricultural lands in private ownership hold great potential for production of ducks and other wildlife if land use is manipulated to provide a secure nesting environment. In this regard a statement presented by Borden and Hochbaum (1966) is pertinent: "Our aim in waterfowl management must be not simply to seek ever more birds from the north, but to produce more per square mile on the reduced but still prime range of agricultural and urban areas of middle latitudes." It is axiomatic that vegetation management is basic to achieving a maximum production of wildlife per unit of land.

Lands retired from crop production under the Soil Bank Program, the Feed Grain Program and the Cropland Adjustment Program have demonstrated the high value of such areas as wildlife habitat. At a time when many grain crops are in surplus supply and duck populations are decreasing, maximum conversion of cropland to idle herbaceous cover should be encouraged.

ACKNOWLEDGMENTS

I wish to extend my appreciation to H. W. Miller and G. A. Sherwood who provided valuable editorial advice. Bruce Burkett helped with all field work and Rodney King assisted with the June 4 nest search.

LITERATURE CITED

Borden, R. and H. A. Hochbaum
1966. Gadwall seeding in New England. Trans. N. Am. Wildl. Conf. 31:79-88.

Evans, R. D. and C. W. Wolfe
1967. Waterfowl production in the rain-water basin of Nebraska. J. Wildl. Mgmt. 31: 788-794.

Gates, J. M.
1965. Duck nesting and production on Wisconsin farmlands. J. Wildl. Mgmt. 29:515-523.

——— and G. E. Ostrom
1966. Feed Grain Program related to pheasant production in Wisconsin. J. Wildl. Mgmt. 30:612-617.

Hochbaum, H. A. and E. F. Bossenmaier
1965. Waterfowl research—accomplishments, needs, objectives. Trans. N. Am. Wildl. Conf. 30:222-229.

Jaenke, E. A.
1966. Opportunities under the Cropland Adjustment Program. Trans. N. Am. Wildl. Conf. 31:323-331.

Job, H. K.
1898. The enchanted isles. The Osprey 3(3):37-41.

Joselyn, G.B. and J. E. Warnock
1964. Value of Federal Feed Grain Program to production of pheasants in Illinois. J. Wildl. Mgmt. 28:547-551.
Keith, L. B.
1961. A study of waterfowl ecology on small impoundments in southeastern Alberta. Wildl. Monographs No. 6. The Wildlife Society, Washington, D. C. 88 pp.
Moyle, J. B., ed.
1964. Ducks and land use in Minnesota. Tech. Bull. No. 8. Minnesota Dept. of Cons., St. Paul, Minnesota. 140 pp.
Schrader, T. A.
1960. Does Soil Bank aid pheasants? Minnesota Cons. Volunteer 23(134):34-37.
Shaw, S. P. and C. G. Fredine
1956. Wetlands of the United States—their extent and their value to waterfowl and other wildlife. Circ. 39, U.S. Fish and Wildlife Service. Washington. D.C. 67 pp.
Weller, M. W.
1956. A simple field candler for waterfowl eggs. J. Wildl. Mgmt. 20:111-113
———and C. S. Spatcher
1965. Role of habitat in the distribution and abundance of marsh birds. Spec. Rept. No. 43, Ag. and Home Econ. Exp. Sta., Iowa State Univ., Ames, Iowa. 31 pp.

MR. D. O. RETTINGER (New Mexico): Harold, in connection with your research, would what you have learned from this and your experience in the soil bank plan have implication to management that would help form guidelines for any programs? What I am thinking of is a ten-year soil bank program, where we might get into a stable situation with introduced grasses.

MR. DUEBBERT: My written presentation is a little different than what I presented orally. As I pointed out, the study is only a single example of what happens as I indicated it. However, I also believe it is representative.

As a general observation, I have found that soil bank land that has been retired for eight to ten years has actually become relatively sterile of wildlife. We plan to follow this particular CAP field to its completion and perhaps will gain some insight into exactly what the proper stage of ecological succession is. We don't know for sure, but we suspect it may be somewhere around the second or third year. The first year doesn't seem to be especially productive because it hasn't had a chance to accumulate the factors I have mentioned. However, I am sure we are going to find future implications not only for future land retirement programs but also for managing state and federal lands.

MR. EARL T. ROSE (Iowa Conservation Commission): Do you have any recommendations for state-owned marshes that have reached more or less the climax in vegetative history on plantings that might enhance such areas—for instance, the planting of clover around marshes?

MR. DUEBBERT: During the next field season we will be initiating studies that we hope will give us some of the answers. I believe that the early successional stages are highly productive. I am not too familiar with the ecology in Iowa, but I believe, at least in many cases, the same management techniques would be productive of birds. Certainly, for example, native grasses have a high aesthetic appeal. In areas which we manage for waterfowl, I believe that a good cover of herbaceous vegetation, consisting of legumes and weeds, is perhaps one of the most productive cover types we have.

MR. RALPH W. DIMMICK (Tennessee): In the Southeast we have trouble determining just what kind of management is required on the retired cropland. We get readings that say we can hold off any management in Tennessee, and yet I and perhaps other state people are required to mow or cut brush and do other kinds of management activities, some of which are not compatible with good management. I wonder if you could clarify this situation.

MR. DUEBBERT: I was hoping nobody would ask me anything in relation to that matter. I must confess that I am not conversant with all practices which are permitted or not permitted. However, I know that spread of noxious weeds is one fear that adjacent landowners always have, and the clipping of weeds is one practice that is permitted on some of the lands which, if done at the wrong time of the year, is certainly detrimental to nesting birds.

MR. CHESTER WRIGHT (Department of Agriculture, Washington, D.C.): I have administered part of the Cropland Adjustment Program and maybe I can help the gentleman with regard to practices in the state that are beneficial to wildlife and so on. These are initiated at the state level, and the wildlife agencies are invited to attend these developmental sessions and instigate certain types of practices they like to see on the retired land. This would then be your approach from the state level—meeting with your state ASCS development group. They develop the agricultural conservation programs as well as the programs that are instituted on Cropland Adjustment Programs retired acreage.

SEASONAL CHANGES IN RUMEN CHEMICAL COMPONENTS AS RELATED TO FORAGES CONSUMED BY WHITE-TAILED DEER OF THE SOUTHEAST

R. L. KIRKPATRICK[1] AND J. P. FONTENOT[2]
Virginia Polytechnic Institute, Blacksburg; and

R. F. HARLOW
Southeastern Forest Experiment Station, U.S. Forest Service, Blacksburg, Virginia

The role of various nutrients in maintaining healthy, productive deer herds and methods of determining the nutritional status of these herds have received considerable attention in recent years. However, our knowledge of deer nutritional needs and nutrient availability in the wild is very incomplete, especially as these characteristics change from season to season. In more northerly climates winter appears to be the period of greatest nutritional inadequacy. In some areas, however, deficiencies of spring and summer deer ranges have been suggested also (Julander *et al.*, 1961; Klein, 1962; Verme, 1967). In the Southeast, little work has been done to determine the nutritional status of deer throughout the year. The present study was conducted to describe and relate seasonal variations in the chemical composition of rumen contents to types of forages consumed by white-tailed deer from six areas of the Southeast.

The use of crude chemical analyses of rumen contents in the evaluation of ranges has limitations since it has been shown that the crude protein content of the rumen digesta may be two to three times higher than that of the forages consumed (Bissell 1959; Silver 1967). The higher apparent protein content of rumen digesta has been shown to be due to the presence of large amounts of microbial protein and smaller amounts of soluble nitrogen in the rumen (Weller *et al.* 1958; Klein, 1962). However, Klein (1962) found that chemical analyses of

[1]Department of Forestry and Wildlife, VPI
[2]Departments' of Animal Science and Biochemistry and Nutrition, VPI

rumen contents of mule deer from two ranges of known quality reflected the differences in these ranges. Klein also discussed in detail various factors which affect levels of chemical components of the rumen contents and concluded that the chemical analysis technique could be used advantageously to compare nutritional differences in ranges between areas, seasons and years. Brüggemann *et al.* (1968) recognized that crude chemical analysis of rumen contents could be a useful technique for nutritional studies in the post mortem ruminant and also pointed out advantages and disadvantages of the method. Thus, even though one cannot determine the exact proportions of various chemical components of the ingested forages in this manner, chemical analysis of the rumen digesta has been shown to reflect differences in forage quality and the general nutritional status of ruminants on a relative basis.

MATERIALS AND METHODS

Field Phase:

Materials for this study were obtained from a total of 120 white-tailed deer collected by shooting at night with a high-powered rifle.[3] Five deer were killed in each of six areas of the southeastern United States during each of the four seasons of the year (Table 1). Collections were made from one area each week for six successive weeks during each season in the following order: (1) A. P. Hill Military Reservation, Virginia; (2) Forks Game Management Area, South Carolina; (3) Chocolocco Game Management Area, Alabama; (4) Daniel Boone Game Management Area, North Carolina; (5) Eglin Air Force Base, Florida; and (6) Fort Stewart Military Reservation, Georgia. The spring collections were made between April 17 and May 23, 1967, the summer collections between July 17 and August 22, 1967, the fall collections between October 16 and November 21, 1967, and the winter collections between January 15 and February 20, 1968. The time each animal was killed was recorded, and all deer were placed in walk-in refrigerators or on ice blocks within approximately one hour after death to retard rumen microbial action.

Necropsy was performed the following day. At that time a visual estimate of body condition was made, and each deer was classed as being in excellent, good, fair, or poor condition. The contents of the rumen were emptied into a large container and thoroughly mixed after evisceration of the animal. A one-quart sample of rumen contents was placed in a plastic bag, labeled and frozen immediately for future chemical analysis. A second quart sample of rumen

[3]These deer were collected under the direction of Dr. Frank Hayes, Dircetor, Southeastern Cooperative Wildlife Disease Study, School of Veterinary Medicine, University of Georgia, Athens, Georgia, as part of that group's disease research work. The materials used in this study were made available through the courtesy of Dr. Hayes.

contents was placed in ten percent formalin for future food habits determination.

Laboratory Phase:

The frozen sample of rumen digesta was thawed, and a portion freeze-dried for determination of dry matter. Crude protein, ether extract, ash and nitrogen-free extract were determined on the dry contents by A.O.A.C. (1965) methods. Crude fiber determination was by the method of Whitehouse *et al.* (1945). Each of the above components was expressed as a percentage of the total by weight.

The formalin-preserved rumen samples were placed in a 6.35-mm. sieve and washed. That portion passing through the sieve was measured by water displacement and classified as unidentifiable finely ground material. This was then expressed as percent volume of the total rumen sample. All items retained by the sieve were separated into plant part and species where possible and measured by water displacement. These were then classed into the following seven categories: leaves of woody plants, herbaceous stems and leaves, mushrooms, acorns, grasses and legumes, soft fruits, and succulent woody stems and buds. In order that these categories could be compared from season to season, each was expressed as the percent volume of total *identifiable* material. In so doing the assumption was made that the unidentifiable finely ground portion was composed of the same proportions of forages as the identifiable portion.

The time of kill for each animal was coded for statistical analysis as follows: 5:00 p.m.-5:59 p.m.[4] = hour 1; 6:00 p.m.-6:59 p.m. = hour 2; etc. The visual estimate of body condition was coded as follows: excellent = 4, good = 3, fair = 2, poor = 1. All data were analyzed by analysis of variance and Duncan's multiple range test (Steel and Torrie 1960). Within subgroup correlation coefficients were calculated between some of the characteristics studied.

Area comparisons were not emphasized in these data since they were confounded with time (succeeding areas were always collected one week later than the preceding area). Seasonal comparisons are discussed in terms of the overall average of all areas. Points of marked difference between seasonal changes in specific areas and the overall seasonal trends are noted.

RESULTS

Time of Kill and Unidentifiable Material

Two initial questions concerning the validity of the food habits and rumen chemical analyses were as follows: (1) Does the time of day

[4]Time was recorded as Eastern Standard except at Chocolocco GMA and Eglin AFB. Time at these areas was recorded as Central Standard.

that deer are killed influence the amount of unidentifiable finely ground material found in the rumen? (2) Are either time of kill or the amount of unidentifiable finely ground material related to the proportions of the various chemical components or the forages found in the rumen?

The answer to the first question was "no" as evidenced by the correlation of 0.02 between time of kill and percent of unidentifiable finely ground material. The answer to the second question was somewhat more vague but was in general "no" also. Time of kill was significantly correlated only with crude fiber ($r = -0.33$, $P<.01$). Although this correlation was highly significant it shows that less than 11 percent of the total variation in crude fiber content was explained by its relation to time of kill. Unidentifiable finely ground material was significantly correlated with crude fat ($r = -0.33$, $P<.01$), ash ($r = 0.28$, $P<.05$), and acorns ($r = -0.31$, $P<.05$). Again these correlations are relatively small, so time of kill and amount of unidentifiable finely ground material are not considered to have appreciably affected either the relative amounts of food items in the rumen or the results of the chemical analyses.

The average time of kill did not change significantly from season to season and was quite variable from area to area within season (Table 1). The amount of unidentifiable finely ground material in the rumen did change significantly with season. The average spring value of 11.3 percent was significantly lower and the average winter value of 41.5 percent was significantly higher than the summer and fall values of 26.9 and 27.8 percent, respectively. Deer from four of the six areas studied had very high amounts of unidentifiable finely ground material in the rumen during the winter season and those from one area (Forks GMA) had a very low amount. The reason for these marked area differences during this season is not known.

Forages Consumed:

Leaves of woody plants made up the largest segment of the rumen digesta although utilization from area to area was variable. The percent of these was significantly higher in the spring (52.8 percent) than in the summer, fall and winter (39.9, 14.1 and 39.4 percent, respectively). The fall value was significantly lower than the summer and winter values.

The percent of herbaceous stems and leaves in the digesta was also significantly higher in the spring (31.8 percent) than during the other three seasons. The summer value (11.7 percent) was significantly greater than that of the fall (2.4 percent) but was not significantly different from that of the winter (5.5 percent). The use of herbaceous stems and leaves was particularly high at A. P. Hill and Fort Stewart in the spring where the use of leaves of woody plants was comparatively low.

The percent of mushrooms in the rumen digesta was greatest [$P<.5$ for the summer season (29.2 percent)] and lowest ($P<.05$) for the spring season (0.3 percent). Fall and winter values fell between these extremes (8.1 and 9.2 percent, respectively). Mushrooms were particularly abundant in rumens of deer taken at A. P. Hill, Forks GMA, and Chocolocco GMA during the summer.

Acorn usage was by far the greatest during the fall ($P<.05$). This item made up 61.6 percent of the rumen digesta at that time. The percent for the winter season (18.2 percent) was also significantly greater than those of spring and summer (1.6 and 0.2 percent, respectively).

The use of grasses and legumes was sporadic, with sizable quantities being consumed only at Chocolocco GMA and Fort Stewart during the winter, at Chocolocco GMA during the spring, and Eglin AFB during the summer. Soft fruits also were used sporadically, with the highest consumption being at A. P. Hill during the winter and summer seasons. Succulent woody stems and buds composed only 8.2 percent of the diet in the spring and progressively decreased during the other three seasons. A detailed presentation of these food habits data will be included in a larger report of food habits of southeastern deer to be published by the Southeastern Forest Experimental Station (Cushwa *et al.* 1969).

Rumen Chemical Components:

The average dry matter of the rumen contents changed significantly over the seasons (Table 1). Values were lowest in the spring and summer (14.3 and 13.8 percent, respectively) and highest in the fall (24.3 percent). The average winter dry matter (18.6 percent) was intermediate. The only area exception to the above was at Eglin Air Force Base where the winter dry matter content was slightly higher than that of the fall.

Average crude protein values were significantly different between all four seasons, being highest in the spring and summer (26.1 and 24.5 percent, respectively, lowest in the fall (14.3 percent) and intermediate in the winter (17.3 percent). In general, all areas followed this same trend although differences between fall and winter values were slight in some areas.

Crude fiber content, which is generally considered to be inversely related to dry matter digestibility, was significantly lower in the spring and summer (19.3 and 19.4 percent, respectively) than in the

TABLE 1. SEASONAL CHANGES IN THE COMPOSITION OF THE RUMEN DIGESTA, TIME OF KILL AND PHYSICAL CONDITION OF WHITE-TAILED DEER IN SIX AREAS OF THE SOUTHEAST[a]

Season and Area	Time of kill	Unidentifiable finely ground material	Leaves of woody plants	Herbaceous stems and leaves	Acorns	Mushrooms	Grasses and legumes	Soft fruits	Succulent woody stems and buds	Dry matter	Crude protein	Crude fat	Crude fiber	Ash	Nitrogen free extract	Physical Condition
Spring																
A. P. Hill MR, Va.	6.4	2.8	11.9	82.6	0	0	0	0	5.5	—	28.4	6.1	20.3	12.0	33.3	2.2
Forks GMA, S.C.	7.0	5.9	56.7	37.3	0	0.2	0	0	5.8	13.6	28.9	7.3	18.7	12.8	32.3	3.0
Choc. GMA, Ala.	5.6	21.4	55.6	15.5	0	0	21.8	0	7.0	15.0	28.0	7.8	16.7	11.9	35.6	2.0
D. Boone GMA, N.C.	6.8	7.9	83.9	0	9.6	0	0	0	6.6	16.4	25.9	7.5	19.7	10.2	36.6	2.8
Eglin AFB, Fla.	5.2	18.0	84.4	0	0	1.4	0.5	0.2	13.4	13.3	24.1	5.8	19.3	11.5	39.3	3.0
Ft. Stewart MR, Ga.	6.0	11.8	24.6	55.1	0	0	0.3	9.1	10.9	13.2	21.4	7.7	21.3	10.9	38.8	2.8
MEAN	6.2[b]	11.3[b]	52.8[b]	31.8[b]	1.6[b]	0.3[b]	3.8[b]	1.5[b]	8.2[b]	14.3[b]	26.1[b]	7.0[b]	19.3[b]	11.5[b]	36.0[b]	2.6[b]
Summer																
A. P. Hill MR, Va.	7.8	25.5	9.7	20.9	0	40.0	0	19.2	3.5	—	24.4	6.4	21.1	10.0	38.2	2.8
Forks GMA, S.C.	8.0	29.4	47.0	0	0	33.4	0	5.0	13.0	14.0	26.5	5.9	18.9	12.0	36.7	3.2
Choc. GMA, Ala.	4.4	26.0	10.5	5.6	0	71.2	11.4	1.3	0	12.1	27.8	8.0	15.6	12.5	36.1	2.4
D. Boone GMA, N.C.	6.8	15.4	82.2	0.2	0.4	10.6	6.6	0	0	15.0	25.1	7.7	18.8	10.5	37.9	2.6
Eglin AFB, Fla.	5.4	33.5	24.1	37.1	0	10.4	25.2	3.2	0	14.5	22.8	7.2	20.8	12.0	37.3	2.4
Ft. Stewart MR, Ga.	6.2	31.4	65.5	6.1	0.7	9.7	0	2.8	12.7	13.4	20.6	8.8	21.1	11.0	38.4	2.0
MEAN	6.4[b]	26.9[c]	39.9[c]	11.7[c]	0.2[b]	29.2[c]	7.2[b]	5.2[b,c]	4.9[b,c]	13.8[b]	24.5[c]	7.4[b]	19.4[b]	11.3[b]	37.4[b]	2.6[b]
Fall																
A. P. Hill MR, Va.	6.2	37.5	12.2	9.3	52.3	2.5	1.5	14.5	7.5	—	17.6	5.9	16.5	5.6	54.3	3.6
Forks GMA, S.C.	7.4	37.0	42.7	2.5	43.7	2.6	0.3	0	7.5	22.3	16.3	8.4	21.9	9.0	44.4	3.0
Choc. GMA, Ala.	4.4	17.1	0.6	0	87.7	0.5	2.7	8.6	0	29.0	12.7	6.9	25.7	4.9	49.9	3.0
D. Boone GMA, N.C.	7.2	37.3	22.0	0	51.4	7.0	14.8	3.9	0.4	21.7	14.7	8.4	22.0	6.3	48.6	3.4
Eglin AFB, Fla.	4.0	19.0	3.9	2.4	48.4	26.7	6.8	9.8	2.0	23.2	11.4	11.2	29.7	7.9	39.9	2.8
Ft. Stewart MR, Ga.	4.6	19.1	3.3	0.1	85.8	9.0	0	0.7	1.1	25.4	13.1	7.3	20.2	6.6	52.7	2.6
MEAN	5.6[b]	27.8[c]	14.1[d]	2.4[d]	61.6[c]	8.1[d]	4.3[b]	6.3[b,c]	3.1[c,d]	24.3[c]	14.3[d]	8.0[b]	22.6[c]	6.7[c]	48.3[c]	3.1[c]
Winter																
A. P. Hill MR, Va.	3.8	20.0	38.3	0.1	9.5	0	0.4	51.6	0	—	17.7	7.5	22.6	9.1	43.1	3.6
Forks GMA, S.C.	6.8	1.0	86.4	0	0	10.7	2.4	0.4	0	14.8	22.7	9.1	20.6	11.8	35.9	3.4
Choc. GMA, Ala.	4.2	50.3	6.5	0.7	42.2	17.4	32.1	0	0	16.8	14.8	5.4	20.0	10.8	49.0	2.8
D. Boone GMA, N.C.	9.0	61.0	58.9	12.3	16.6	0	0	0	3.9	16.7	14.9	6.2	24.3	11.0	43.6	2.6
Eglin AFB, Fla.	3.4	56.8	21.4	20.0	41.1	13.2	1.8	2.4	0	24.1	16.5	7.6	23.9	8.8	43.2	3.0
Ft. Stewart MR, Ga.	4.0	59.6	24.6	0	0	13.8	58.6	0	0	20.5	17.3	7.0	23.6	16.3	35.8	2.8
MEAN	5.2[b]	41.5[d]	39.4[c]	5.5[c,d]	18.2[d]	9.2[d]	15.9[c]	9.1[c]	0.7[d]	18.6[d]	17.3[e]	7.1[b]	22.5[c]	11.3[b]	41.8[d]	3.0[c]

[a] See text for explanation of areas, units of measurement and sample size.

[b,c,d,e] Seasonal means bearing different superscripts are significantly different from each other ($P < .05$).

fall and winter (22.6 and 22.5 percent, respectively). However, this characteristic was quite variable among areas during the fall season. Average crude fiber values actually decreased from summer to fall at A. P. Hill and Fort Stewart. Also, crude fiber increased from fall to winter in three areas and decreased in the other three, due primarily to the area variability in the fall values.

Average crude fat (ether extract) values did not change significantly over the four seasons and averaged between 7 and 8 percent. Average ash values were significantly lower in the fall (6.7 percent) than those for the other three seasons (all slightly greater than 11 percent).

In general, nitrogen-free extract values were inversely related to crude protein. Average nitrogen-free extract contents were significantly lower in the spring and summer (36.0 and 37.4 percent, respectively) than those of the fall and winter (48.3 and 41.8 percent, respectively). The fall value was also significantly higher than the winter value.

Physical Condition:

The visual estimate of physical condition was significantly different between spring-summer killed deer and fall-winter killed deer. The coded mean value of 2.6 for the spring and summer estimates indicated that deer killed during these seasons were between fair and good condition, whereas the average values of 3.1 and 3.0 for the fall and winter killed deer, respectively, indicated that they were in good condition.

DISCUSSION

Both the forage and nutritional compositions of the diet of these deer (as estimated by analyses of the rumen digesta) changed markedly throughout the year. The spring and summer diets appeared similar nutritionally, although their forage compositions were different. Both diets were apparently relatively low in dry matter, crude fiber and nitrogen-free extract and relatively high in crude protein. The principal spring foods were leaves of woody plants and herbaceous stems and leaves, whereas leaves of woody plants, mushrooms, and herbaceous stems and leaves comprised most of the summer diet. Hence the substitution of mushrooms for leaf and stem material had little apparent effect on the chemical composition of the rumen contents.

Probably the most striking characteristic of the rumen digesta of deer consuming these diets was the very low dry matter content. This low dry matter would likely necessitate the consumption of large quantities of forage to fulfill the nutrient requirements of deer during these seasons. This would be true especially in the case of the producing female as nutrient needs increase substantially in late gestation and early lactation. The poorer estimated physical conditions of deer during these seasons would tend to confirm that the nutrient intake may not have met the nutrient requirements of the animals at that time. Additional quantitative data on physical condition such as percentage of bone marrow fat and liver glycogen levels would cast additional light on this point.

The fall diet differed markedly from the spring and summer diets both in forage composition and apparent nutritive value. This diet was much higher in dry matter, crude fiber and nitrogen-free extract and lower in crude protein. Acorns made up almost two thirds of this diet with leaves of woody plants and mushrooms contributing smaller quantities. The chemical composition reflects the large amount of acorns in that they are relatively lower in protein and higher in nitrogen-free extract and dry matter than most leaf material. The average estimated physical condition of the deer was good (higher than spring-summer values) as one would expect in animals eating an energy rich diet.

Generally, the winter diet appeared intermediate in nutrient value compared to the spring-summer and fall diets. Dry matter, crude protein, and nitrogen-free extract fell between the extremes for the other diets while the crude fiber content was similar to that of the fall diet. The winter diet was quite varied in composition being composed primarily of leaves of woody plants, acorns, grasses and legumes, mushrooms, and soft fruits. The average estimated physical condition of deer killed during winter was also good indicating perhaps that deer in the Southeast go through most of the winter in good condition and lose fat reserves only in late winter and early spring.

SUMMARY

Five deer were killed in each of six areas of the southeastern United States during each of the four seasons of the year. Samples of rumen contents were obtained and analyzed for forages consumed and crude chemical components. Time of kill and an estimate of body condition were also recorded. Leaves of woody plants and herbaceous stems and leaves comprised the major part of the spring diet, whereas leaves of woody plants and mushrooms formed the bulk of food consumed during the summer months. Acorns were the largest component of the fall diet comprising over 60 percent of the total identifiable items consumed. The winter diet proved to be the most varied, with leaves of woody plants, acorns and grasses and legumes contributing the major portion. Dry matter and the various chemical components of

the rumen digesta remained relatively constant from spring to summer in all six areas. Fall samples were markedly different, however, having higher dry matter and nitrogen-free extract and lower crude protein and ash values. Crude fiber values increased only slightly during the fall and winter months, and crude fat remained relatively constant during all four seasons. Crude protein and nitrogen-free extract values for the winter months were intermediate between the spring-summer and fall levels. Seasonal changes in estimated physical condition indicated that deer were in better condition in the fall and winter than in spring and summer.

LITERATURE CITED

A.O.A.C.
1965. Official methods analysis (9th Edition). Association of Official Agricultural Chemists. Washington, D.C.

Bissell, H.
1959. Interpreting chemical analysis of browse. California Fish and Game. 45:57.

Bruggemann, J., D. Giesecke, and Karin Walser-Karst
1968. Methods for studying microbial digestion in ruminants post mortem with special reference to wild species. J. Wildl. Mgmt. 32:198.

Cushwa, C. T., R. L. Downing, R F. Harlow and D. F. Urbston.
1969. U.S.D.A. Forest Serv. Southeast Forest Exp. Sta. Note. In press.

Julander, O., W. L. Robinette and D. A. Jones.
1961. Relation of summer range condition to mule deer herd productivity. J. Wildl. Mgmt. 25:54.

Klein, D. R.
1962. Rumen contents analysis as an index to range quality. Trans. N. Am. Wildl. and Nat. Resources Conf. 27:150.

Silver, Helenette
1968. Deer nutrition studies. In *The White-tailed Deer of New Hampshire.* H. R. Siegler, ed. N. H. Fish and Game Dept.

Steel, R. G. D. and J. H. Torrie
1960. *Principles and Procedures of Statistics.* McGraw Hill Book Co.. Inc. New York.

Verme, L. J.
1967. Influence of experimental diets on whitetailed deer reproduction. Trans. N. Am. Wildl. and Nat. Resources Conf. 32:405.

Weller, R. A., F. V. Gray and A. F. Pilgrim
1958. The conversion of plant nitrogen to microbial nitrogen in the rumen of the sheep. British J. Nutr. 12:421.

Whitehouse, K., A. Zarow and H. Shay
1945 Rapid method of determining "crude fiber" in distillers' dried grain. Journal of Association of Official Agricultural Chemists. 28:147.

DISCUSSION

MR. ED KUNI (Outdoor Writer; Chairman of the Committee on Better Deer Hunting, Pennsylvania): The consensus of most research experts on nutrition found in most artificial feeding of white-tailed deer during the winter when they are on short rations bordering on starvation diets that their physiology depends on friendly bacteria to digest the food. However, during the winter months, when they are lacking a lot of friendly bacteria, some good-hearted sportsman gives them a rich diet, which invariably makes them starve or die with stomachs full of corn. Now, in Michigan, in the past few months, they experienced one of the worst winters in twenty to forty years. The wildlife people there sanctioned the sportsmen taking federally purchased surplus corn into the deer yards, where the deer are herded up. In other words, I would like your comments on this corn business.

DR. KIRKPATRICK: I don't know that I can add any more than what you have already said. As you know, at least in the South in general, we do not have the problem of winter starvation as in other areas. I don't have anything to add other than the point already indicated—that the micro-organisms are at a low level in starving deer, and the food found in the rumen cannot be utilized.

DR. JOHN KITCHELL (President, Michigan United Conservation Clubs): I would like to defend our winter feeding. Corn was obtained from federal depots, but it was carefully scattered in order that no deer would gorge on it. It was combined with the cutting of browse in the area so the deer did get a variety of diet. The only good reason for using corn is that it is much more readily available than bean pods and other things that might be more nutritious for the deer.

MR. WILLIAM W. MAUTZ (Michigan): I would like to comment on this. I have been working with white-tailed deer at different levels of food consumption. What you are repeating is a direct problem of possibly too much at one time. I have starved animals to a relatively low level and then presented them with unlimited amounts of food. They gorged themselves and then went off their feed for several weeks. This is a problem with feed-lot cattle as well. Also, time of the year is another large factor. If animals are not fed until their condition is very low, then it would be better not to feed them at all.

MR. FRANK BARICK (North Carolina): I was interested to see that about 15 percent of the winter rumen contents consisted of grasses because we plant pastures on management areas for deer. I was wondering if this can be taken then as some support for pasture planning as a management practice? A few years ago there was some research attempted which started to indicate that pasture planting was not particularly effective. I don't recall that the research was ever completed, but I wonder now if this is an indication that possibly pasture planting is a beneficial management practice.

DR. KIRKPATRICK: I have just one comment to make on this and that is that the use of grasses was very sporadic, and there didn't seem to be much rhyme or reason to it. There were no grasses consumed during the winter months by the North Carolina deer although the sample is small. There were some consumed during fall, and very little during the other two seasons. However, availability in the collection areas was not known.

MR. KENNETH WILSON (North Carolina): On our management area, which is also U.S. Forest Service-owned under cooperative agreement, we have about 120 acres of pasture. During years we have had good crops, the deer ate corn at heavy rates. This year we had virtually no corn, and last month I checked some of the pastures and we found dropping in fescue so numerous in some pastures that you could hardly put a hand down. Obviously the grass was nibbled down to about a quarter of an inch or less. Therefore, in my opinion, we might also say that without the pastures during the winter, I don't know what would have happened to our deer.

TECHNICAL SESSION

Tuesday Morning—March 4

Chairman: Bruce T. Wilkins

Assistant Professor of Conservation, Cornell University, Ithaca, New York

Discussion Leader: Ross Manes[1]
Information Officer, Arizona Game and Fish Department, Phoenix

MEASURING WILDLIFE VALUES—QUANTITY AND QUALITY

REMARKS OF THE CHAIRMAN

BRUCE T. WILKINS

Many people, I believe, agree that the quality of life, the quality of our environment, is a major concern to resource management. We seem agreed on the concern, on the goal, but our means of measuring progress are very imprecise. Indeed, I know of no current definition which accurately describes for operational purposes just what quality is.

It surely is not some intrinsic immutable law awaiting discovery; no, the definition must reside in people and if in people, then ecologists surely cannot be guaranteed to have the greatest skill or insight into probing the problem. For if quality is an ideal that an individual holds, presumably, in a democracy, quality as measured by each person has weight. Thus, operational policy pertaining to natural resources may be altered not only by the biologist with his biases, but by other persons, too.

Our first paper describes such a situation—a hot potato to many—a concern somewhat inimicable to the biases that many of us bring to natural resources. We think it provides an excellent example of a pragmatic attempt to alter this measure of quality.

[1]Mr. Manes substituted for J. W. Sizer, Chief of Information and Education, Arizona Game and Fish Department, who was unable to attend owing to illness.

PUBLIC PRESSURE AND A NEW DIMENSION OF QUALITY—HORSES AND BURROS

VELMA B. JOHNSTON
International Society for the Protection of Mustangs and Burros, Reno, Nevada; and
MICHAEL J. PONTRELLI
University of Nevada, Reno

Horses, and to a lesser extent, burros, are symbols of the West. These animals are a part of our heritage and represent a dimension of quality in the environment. Many people think of them as native wild animals, and this conception is understandable when it is realized that horses and burros were among the first introductions by man into North America.

When free-ranging, unbranded horses and burros are classified as feral or exotic animals, a semantic problem of the layman's understanding versus scientific or legal terminology arises. Feral livestock is still livestock and not wildlife. Exotic animals, especially non-game exotics, are frequently considered unwanted intruders. For example, as feral or exotic, horses and burros are not welcome in national parks. Management policy in national parks is that exotics are not be be encouraged and feral animals are regularly removed (Leopold *et al.*, 1963).

State legislative action has usually classified horses and burros as feral or estray livestock under the jurisdiction of state departments of agriculture. Since domestic horses and burros can escape and be assimilated into wild bands, this classification is logical.

Horses evolved in North America, and Dasmann (1964 reported that the last native horses disappeared only 8,000 years ago. Burros probably evolved in arid regions of North Africa and were adapted to conditions they found in the arid Southwest United States.

The history of the modern horse on the North American continent is shrouded in conjecture and contradictory opinions. Columbus is credited with having brought the first horses to the New World. But, the first horses to reach the mainland of North America probably were brought from Cuba by Cortez (Wyman, 1945).

Horses escaped into the wild and came to be known as "mustangs," a word that originated with the Spanish *mesteno* meaning "strayed—wild." The terms are used interchangeably in this paper.

The Indian was quick to take advantage of this new resource, and it seems as if the horse and the American Indian have always been together. Allen (1954) said that horses were the cultural key that gave the Indian the full use of his environment.

With the westward march of civilization, settlers found the bands of free-running, wild horses to be a nuisance and began killing them by the thousands (Wyman, 1945). Driven to the most remote environments, only the hardiest survived. Underfed and scrubby, "broomtail," "cayuse" or "jughead" were terms that described them well.

At the end of World War II and during the years immediately following, the demand for horse meat for pet food became overwhelming. The commercial exploitation factor that would bring about the possible extinction of the wild horse had now entered the picture.

Horse removal served two purposes: more grazing land would be come available for domestic users; and horse carcasses provided cheap meat for the processors. It was a lucrative business for the professional hunters, as the only requirements at the slaughtering centers were that the animals be ambulatory and in large numbers. The old technique of rounding up horses with crews of hard-riding horsemen was too slow and costly, so the cowboy took to the air. They drove horses from their meager shelter in the rimrock and canyons, and to expedite taking large numbers, used inhumane methods. Physical injuries were the least concern as these animals were to be killed anyway. By 1949, in Nevada alone, more than 100,000 unowned horses were captured and processed (McKnight, 1964). Throughout the West, where their numbers had been estimated in the millions (Wyman, 1945), they had been reduced to an estimated 14,810 to 28,620 (McKnight, 1959).

Even though the burros were not commercially exploited, they fared no better than the horses. Claims of overpopulation and possible competition with the native desert bighorn led to systematic extermination programs. In California, the public reacted unfavorably to these programs, and, in 1953, broadly protective legislation for the burros was passed. In 1957, the California legislature established a wild burro sanctuary on two million acres of Federal Public Domain. In this case, complete protection, without management, is certainly no panacea. Many observers agree the burros often seem too numerous.

The following is the personal story of Mrs. Johnston. The end result is a demand backed by great public pressure that the horses and burros be allowed to endure.

Although I had heard that airplanes were being used to capture mustangs, like so many of us do when something doesn't touch our lives directly, I pretended it didn't concern me. But one morning in the year 1950, my own apathetic attitude was jarred into acute awareness. What had now touched my life was to reach into the lives of many others as time went on.

By chance, I drove behind a truckload of bleeding and exhausted horses. My curiosity aroused, I questioned the driver and learned the horses had been caught in an airborne roundup and were destined for slaughter. Outraged, I set about accumulating all the information that was available on the horses, commercial roundups in other areas of the West, methods used, physical abuses, and an estimate of the numbers that were being taken. I learned the removal program was subscribed to by the Bureau of Land Management, which has the responsibility for the protection, management and improvement of the public lands under the terms of the Taylor Grazing Act. This policy was adopted as a result of pressures by the domestic users of the public lands and by hunting interests. McKnight (1964) quoted BLM Nevada State Supervisor, E. R. Greenslet: "This program (of large scale removal) was carried out without cost to the government except some assistance in building holding corrals and truck trails when needed."

The information, though limited, served me well when in mid-June of 1952, I learned of a proposed airplane roundup of wild horses in the Virginia Range of Storey County, adjacent to my ranch. Permission had already been granted by the BLM district office, and Nevada law required that permission also be obtained from the Board of County Commissioners. My husband and I began a crash program to inform and seek the support of as many people in the county as possible. At the permit hearing such a strong protest was registered that the commissioners, on June 16, 1952, outlawed the use of airplanes as a means of chasing, rounding up or spotting during a roundup of wild horses or burros within the county. The victory was not easily won. A group of sheepmen claimed that the horses were injurious to grazing land; and rendering works officials deemed it their right to conduct wild horse chases by airplane, and to corral and transport the animals to rendering works. (*Reno Evening Gazette,* June 10, 1952). It was a small measure of success, but enough to spur efforts to have similar legislation enacted to cover the whole state.

In February, 1955, a bill paralleling the Storey County action was introduced into the Nevada State Legislature, at my request, by State Senator James M. Slattery and was assigned to Committee. Three similar bills backed by other concerned individuals had failed to get out of committee in the past, due no doubt to public apathy. However, I had learned the value of educating the voters to guarantee support and I was willing to try. I wrote to riding groups, humane organizations, prominent citizens, civic organizations and friends. I emphasized that their support must be voiced through their legislators. My efforts to enlist help from the news media failed, except occasionally my "Letter to the Editor" was carried in local newspapers, and the writer of a weekly horseman's column helped in every way possible. I carefully avoided the pitfall of becoming lyrically sentimental over the animals, and I admitted that mustangs would not, in many instances, measure up to accepted standards of equine beauty. I pointed to the lack of knowledge either to repudiate or justify claims that they were injurious to the range. I reasoned that probably because of their feral or exotic status, little scientific attention had been given to them, surprising in view of the vast ranges, large populations and economic importance involved. It was difficult to point to harassment and abuse by man and at the same time hide my emotions. I needed the support of those appalled by inhumane treatment, but I did not want my words to be categorized as emotional, for there were those who would brand me as oversensitive. However, it was my description of inhumane treatment and my reminder of the loss of an American heritage that gained public support.

So strong was the response to my appeal for help that one of the lawmakers remarked to Senator Slattery, "Who is this Mrs. Johnston? She must know everybody in the State!" (Personal comment Senator Slattery).

The Committee chairman agreed to release the bill with a "do pass" recommendation, provided I would agree to an amendment to prevent the act from being construed to conflict with provisions of any federal law or regulation governing hunting or driving of horses or burros by airborne or motor-driven vehicles. At this point, a piece of bread was better than losing the whole loaf, and I agreed to the amendment with the realization that approximately 87 percent of Nevada's land is federally controlled, and only the rest would be protected. The measure passed the legislature with almost no opposition, and on March 23, 1955, the Governor signed into law the first statewide measure ever enacted to prohibit the airborne and mechanized pursuit and capture of wild horses and burros.

It soon became apparent that an effective program for the protection of all wild horses and burros would require the enactment of federal legislation. In view of the relatively small number of people now concerned it was a project that seemed as unlikely of accomplishment as did a trip around the moon at that time. But, each was to become a reality.

We continued to inform as many people as possible. But, it was two years before the story was carried in the nation's newspapers. California's *Sacramento Bee* was the first, February 21, 1957. Then, it was featured by such magazines as *Reader's Digest* (December, 1957) and *True* (June, 1958).

On January 19, 1959, Nevada's Congressman, the Honorable Walter S. Baring, introduced a measure to prohibit use of aircraft or motor vehicles to hunt certain wild horses or burros on all land belonging to the United States. At this point, more publications carried the story. *Desert* (June, 1959), *Sierra, Western Horseman* and *Time* (all July, 1959), and humane organizations and their affiliates were instrumental in awakening interest. European newspapers and magazines covered the story, and as more readers became aware of the plight of wild horses and burros, I received letters by the thousands. To each inquiry of "What can I do to help?", I replied, "Contact your delegations in Washington, ask for an early hearing on HR2725, and solicit the support of your lawmakers when the bill comes up for their consideration." Included also, was the latest information I had and a plea to enlist the help of all with whom the writer might come in contact.

The move to save these animals gained momentum throughout the nation. Similar or identical measures were introduced by Representatives Coad of Iowa, Loser of Tennessee, O'Konski of Wisconsin, and by Senators Mansfield and Murray of Montana, Neuberger of Oregon, Douglas of Illinois, Cannon of Nevada, Cooper of Kentucky and Bush of Connecticut. The fact that Members of Congress reacted affirmatively to their constitutents from so widely separated geographical locations indicated nationwide support.

An Associated Press release of July, 15, 1959 stated, "Some Congressmen hope the matter will be settled soon. Seldom has an issue touched such a responsive chord in the hearts of their constituents. Their offices have been overwhelmed by mail."

The *Christian Science Monitor*, July 21, 1959, "Members of Congress have been startled by an unusual stampede of mail in recent weeks. They have been bombarded with thousands of letters from constituents, not about world affairs, about inflation or taxes—but about wild horses."

The *Kiplinger Washington Letter* of July 18, 1959, "Congress is deluged with protests over use of planes and trucks by hunters who run down range mustangs, rope them, kill them and sell them to processors."

The "Wright Slant on Washington" (a report from Congressman Jim Wright of Texas) July 20, 1959, "Am I going to be susceptible to pressure? . .. You bet your boots I am."

A Congressional hearing was scheduled for July 15, 1959, at which I was summoned to testify. On July 14th, at a news conference, I was interviewed at length by representatives of leading news media. By nightfall, the story of my arrival in the nation's capitol was in nearly every major newspaper throughout the land and on the front page of many.

In the House Judiciary Chamber, with press galleries filled and before a capacity audience, I related the story of the slaughter of the wild horses and burros to the seventeen Congressmen of the committee. It is a matter of record that I stressed the need for knowledge and management as well as humane treatment. For more than two hours, I testified and was interrogated.

Department of the Interior representatives argued for an amendment to allow the BLM to continue the use of airborne and mechanized methods for the capture of the animals. I countered that the amendment would put the stamp of approval of Congress on what had long been going on and would render the legislation useless for the purpose for which it was intended.

On August 11, 1959, the House Committee on the Judiciary unanimously recommended its passage without amendment, and in its report No. 833 included this definition: "The world 'wild' refers to horses or burros existing in a wild or free state on public lands. The language used is broad enough to apply to any horse or burro existing in a free or wild state on public land or ranges, and this plus the requirement that they be unbranded is sufficient to differentiate these horses from horses whose ownership can be traced to some individual. It would be noted that this classification does not rest upon the origin of the horses in terms of bloodlines or similar technical limitations." The bill passed the House on August 17th without debate and the Senate passed it on August 25th. It became Public Law 86-234 with the signature of President Dwight D. Eisenhower on September 8, 1959.

In its slow and stormy course from the Court House of my county to the White House of my country, a course that took seven years and three months, it was the increasing support by public pressure that brought accomplishment.

Interest in the wild ones did not subside once the legislation was enacted. My mail continued to be heavy, and invitations to speak before civic groups multiplied. Many realized that steps to provide for the security of the horses' future would likewise have to be taken and they continued in their demands.

By order of Secretary of the Interior Stewart L. Udall, December, 1962, a 435,000-acre wild horse refuge was established in southern Nevada. A news release from his office had this to say: "The refuge was established in answer to pleas from thousands of admirers of the free-ranging animals, some of whom are thought to be remote descendants of the early Spanish mustangs. . . . To many people, the wild horses are a symbol of an inspiring era in the West."

Located in the northeast corner of the Nellis Air Force Base practice range, northwest of Las Vegas, it was planned to develop the horse refuge into a national park type of attraction and at the same time provide for research and evaluation of resource management practices. (*A Management Plan for the Nevada Wild Horse Range,* prepared by the Nevada State Office, Bureau of Land Management, March, 1966.) In response to my inquiry as to how the plans were progressing, Mr. Boyd L. Rasmussen, Director of BLM in Washington, informed me in his letter of November 30, 1967, "We were well aware of the military requirements at that time, and felt that management of wild horses would be quite compatible since the area is so large. Optimistically, we hoped that military requirements would lessen . . . the Air Force must increase its use of the area . . . and cannot allow public access. For the time being, we must continue the Nevada Wild Horse Range in its present status." The 1966 Management Plan was put aside and is now unavailable.

The next development, and dramatically indicative of the intense interest of the public, was the report in *National Observer* (April 11, 1966) of the long smoldering controversy over some 150 horses in the Pryor Mountains along the Montana-Wyoming border. Residents of the area contended that the horses were descendants of those ranging in the Pryors when some of the first settlers came there in 1894, and they should be allowed to remain as an historical attraction. Montana game officials claimed the horses were depriving the deer of browse. The BLM, contending that the vegetation on the federal land involved required protection, decreed that the horses must be removed. In Lovell, Wyoming, the town nearest to the horse range area, the Chamber of Commerce organized its campaign to resist destruction or removal of the horses.

Almost immediately protest letters criticizing the Bureau's policy began pouring in to the Governors of Montana and Wyoming, the BLM, Congressmen and local officials in the area. In the face of such strong opposition, BLM agreed to postpone decision on the fate of the horses for two years.

BLM in defense of its position on horses and burros in May, 1967 issued *Fact Sheet: Wild Horses.* BLM acknowledged that it shared with may people an interest in preserving and protecting the remnants of the wild horse herd. Any horse roaming free, and uncontrolled could be called a wild horse, and the numbers estimated on public domain were 17,300 horses and 8,100 burros. The fact sheet attributed the drastic reduction in horse density to disease, starvation, roundups, and concluded by saying that solutions to wild horse problems would be found when all concerned could work together.

The April, 1967, issue of *True* magazine related the Pryor Mountain furor. Articles in newspapers appeared from time to time, and as more people became aware of the situation, protective efforts accelerated.

In a nationwide news release, September 14, 1967, BLM announced a four-point policy which assured that positive efforts would continue for the preservation of wild horses and burros. The policy provided for a planned management program where the aesthetic value of wild horses or burros was determined to be a public asset; where forage and water was limited and the wild horses and burros competed with livestock or wildlife, BLM would work with interested groups; where reserved forage is set aside for horses and burros, the Bureau would establish cooperative management agreements with state and local authorities and other interested groups; where numbers become too plentiful, the agency would work with state and local authorities in gathering excess animals to reduce the herds to manageable numbers. The news release was concluded by the Director alluding to BLM awareness of public pressure. He said, "We feel that the public has amply demonstrated its concern for these animals and look upon them as representatives of a colorful and historic chapter in the story of the West."

Hardly was the ink dry on the BLM policy statement, when the Montana Livestock Commission went into action to protect the domestic users of the public land within its borders. On December 4, 1967, the commission resolved that the ownership of livestock, including horses and burros, without specific responsibility, was contrary to the policy of the Livestock Commission of the State of Montana and that in the creation of any refuge area, state lines should be fenced in order to determine jurisdiction and eliminate confusion of responsibility and policy. This was clearly an indication of opposition by the cattle industry in the State of Montana, and timed to particularly affect the Pryor Mountain horses.

Upon expiration of the two-year reprieve the Bureau of Land Management on March 14, 1968 presented three alternatives for managing the Pryor Mountain Horse Area. Referred to by *Newsweek* (May 13, 1968)as a choice of "remove, remover, removest," the first one called for the removal of all but 30 to 35 horses by corral trapping, then to allow an increase to a maximum of 50 to 60 animals when the watershed recovered. The second called for herd reduction to 10 or 15 with a future potential of about 30, and with a healthy deer herd to be maintained; the third called for the removal of all the horses and the introduction of a huntable bighorn sheep herd.

Public clamor grew increasingly bitter and by June, the Bureau had received thousands of letters and had held 24 public hearings. In a news release (June 16, 1968) by the Billings, Montana, District Office of BLM, Dean Bibles, District Manager, stated: "While we have been urged to establish a wild horse refuge in the Pryor Mountains, no group has volunteered to sponsor these horses so far. Because of requirements of Montana livestock law, someone will have to assume responsibility for them." Decision was to be reached in August, 1968.

Upon announcement of the requirement of sponsorship for the herd the Pryor Mountain Wild Horse Association was formed by residents of the area and volunteers from other parts of the country. Late in May, Dean Bibles outlined five requirements that the sponsors would have to meet. Among them were that the horses would have to be purchased from the "State or States" (Montana—Wyoming) and would be branded by the sponsor with a properly recorded brand in both states. Other specific requirements were to be worked out in accordance with BLM's horse policy, (*Lovell Chronicle,* June 20, 1968). We who were willing to sponsor the herd refused to comply with the branding requirement.

In the meantime, construction by BLM of an elaborate corral-type trap at one of the major watering holes was well under way—at an estimated cost of $40,000—(*Casper Star-Tribune,* September 18, 1968). A nationwide ABC-TV news broadcast in July, 1968 featured the Pryor Mountain horses and their possible fate. The public renewed its pleas in their behalf, and the Interior Department was nearly buried in telegrams, letters and telephone calls. Many complaints cited lack of scientific knowledge as a reason to continue to delay action. Work on the trap continued in spite of the many protests. Time for final decision was rapidly drawing near, with preparation for horse capture nearing completion.

All other efforts to halt the BLM having failed, in late August, 1968, the Humane Society of the United States, with Lovell, Wyoming, rancher Lloyd Tillett, filed suit against the Secretary of the Interior and other officials of the BLM to bring the proposed removal program to a stop. At the hearing on the application for a restraining order, BLM officials stated the Bureau had no intention of destroying the mustangs, and that if any decision were made, there would be ample opportunity for all to be heard and all rights to be preserved. Upon this assurance, the temporary injunction was dismissed on the grounds it was premature. Left standing was the petition for a permanent injunction. (*News* of the Humane Society of the United States, September-October, 1968).

Plans for trapping the horses were abandoned, and on September

12, 1968, the BLM announced the establishment by Secretary Udall of a 31,000-acre wild horse and wildlife range in the Pryor Mountains along the Montana-Wyoming border to "give Federal protection to a herd of wild horses whose future has aroused nation-wide attention for several months." The Director said, "It is essential that we move ahead immediately to designate these lands to provide Federal protection for this national heritage." At the same time, the Secretary authorized the appointment of a special advisory committee to help in the study of humane and practical means to operate the range.

The committee, appointed by Director Rasmussen, is comprised of eight members:

William G. Cheney, Executive Officer, Montana Livestock Commission, Helena, Montana; Dr. C. Wayne Cook, Chairman, Department of Range Management, Colorado State University, Fort Collins, Colorado; Dr. Frank C. Craighead, Jr., Wildlife Naturalist, Moose, Wyoming; Frank H. Dunkle, Director, Montana Fish and Game Department, Helena, Montana; Mrs. Velma B. Johnston, President of the International Society for the Protection of Mustangs and Burros, Reno, Nevada; Clyde A. Reynolds, Mayor, Lovell, Wyoming; Mrs. Pearl Twyne, President, American Horse Protective Association, Great Falls, Virginia; George L. Turcott, Chief, Division of Resource Standards and Technology, Bureau of Land Management, Washington,

The committee held its first meeting October 16-20, 1968, in Billings, Lovell and on the horse range. Two more meetings will conclude the preliminary studies and pave the way for the committee's recommendations. With the establishment of an advisory group, one of my major aims these last ten years was reached. I hope the committee will recommend other goals toward which so many have worked, and personally will emphasize the need for study.

The horses and burros have become a dimension of quality in whose behalf the public has expressed itself forcefully and will no doubt continue to do so. That public opinion is a strong factor in the determination of value is dramatically demonstrated in a summary of developments over a comparatively short period of time.

It is significant that twelve years ago a BLM official boasted of the number of horses taken in his agency's program of range clearance (at negligible cost to the government); on September 12, 1968, the BLM Director referred to horses as a "national heritage," and the bureau has expressed interest in trying to save them. Yet there has been no lessening of the pressures against them by other users of the range.

That out of the limbo to which their feral status relegated them, they are now given federal protection in at least two refuge areas.

That from being the victims of indiscriminate reduction programs and the scapegoats for many of the natural ills and domestic abuses that have befallen our public lands, their future in one specific area at least is to be decided only after the most careful consideration by acknowledged experts in their fields.

That where their welfare was once of so little concern as to merit only space afforded to a "Letter to the Editor" in a local paper in the least populated state of our nation, their welfare was the subject of a twelve-page photo essay in *Life* (January 17, 1969) whose circulation numbers in excess of seven million.

That from a long-standing need to establish research from which to manage, the University of Nevada, Reno, has begun an active and broad research interest in mustangs; and the University of Nevada and the University of California, Berkeley, are attempting to initiate intense studies on burros.

Public interest, backed by public pressure, indicates a feral livestock classification will not be accepted, and it is also evident that these animals must be considered desirable exotics, if still exotics. This may mean a federally legislated designation of status. Late in the last session of Congress, I initiated a movement to have these animals classified as endangered wildlife, but it has been pointed out to me that to include these controversial animals under the broad use of the term "endangered wildlife" may injure the concept for other animals which also need protection.

Possibly there is a more acceptable designation which will afford impetus to a program for protection, research and management of mustangs and burros. I will investigate alternatives because public pressure has accelerated in recent weeks.

It is our hope that this presentation will bring to the attention of professional wildlifers that these animals merit their concern.

LITERATURE CITED

Allen, D. L.
1954. Our wildlife legacy, Funk and Wagnalls Co., pp. 422.
Dasmann, R. F.
1964. Wildlife biology, John Wiley and Sons, Inc., pp. 231.
Leopold, A. S., S. A. Cain, C. Cottam, I. N. Gabrielson. and T. L Kimball
1963. Wildlife management in the national parks. Tran. N. A. Wildf. and Nat. Res. Conf. Vol. 28: 29-45.
McKnight, T. L.
1959. The feral horse in Anglo-America. The Geog. Rev. Vol. XLIX (4): 506-525.
———
1964. Feral livestock in Anglo-America. U. Calif. Pub. in Geogr. Vol. 16: 1-78. 7 plates.
Wyman, W. D.
1945. The wild horse of the west. Caxton Printers, Ltd., pp. 348.

DISCUSSION

DISCUSSION LEADER MANES: Thank you, Mrs. Johnston. First of all we would like to call for points of clarification.

DR. DOUGLAS PIMLOTT (University of Toronto): I'm particularly interested in knowing why it was considered to be so important from Mrs. Johnston's point of view that she kept from being emotional in this issue. I think that in all of these issues the most important factor involved is human emotion. Personally, I don't see anything wrong with human emotions when they are well based, and I think this is what is going to enter in public opinion. But we make a studied attempt so often to avoid emotion, and I would like very much to understand why a private citizen would feel so strongly about keeping this very important element out of her presentation on this question.

MRS. JOHNSTON: There isn't a thing wrong with emotion. It is a very important part of our lives; but when a woman begins on it, fighting a man's battle in a man's world, she has three strikes against her to begin with and I had to learn to talk on that level. What feelings I have are something different.

MR. MANNUS: Any other questions?

MISS ANN FREE (Washington *Star*, Baltimore *Sun*): Could Mrs. Johnston and Dr. Pontrelli tell us about the burros? I thought that they got a little short-shirted in the paper.

DR. PONTRELLI: The burros were kind of an adopted son for Mrs. Johnston's concern. There are many groups very interested in burros and concerned about their safety and future. The burros, in fact, were slighted in the paper. They have not had the amount of public pressure generated over them and we made the point of emphasis in the paper public pressure.

I think Wally Macgregor who wants to ask a question next can say in California that's not the case.

We didn't go into it very much. It is a complicated problem. We would have but there was time limitation on how much we could write.

MR. WALLACE MACGREGOR (California): I'm glad Mike made that comment because I was going to jump all over him.

In California it is a greater crime of the fish and game laws to shoot a burro than to shoot a man. The penalty is more severe.

I want to compliment Mrs. Johnston. She pointed out in her paper that complete protection is not a fantasy, and management is required. Since complete protection has been installed in California, the Department has been somewhat negligent in the attention we have given the burros. From a research standpoint we have tried to remedy this. We did contribute to U. C. students last summer. Unfortunately, budget cuts eliminated this for future work. We hope we can do this in a nonfinancial way. We do have a real problem with burros in California and our whole desert ecological system. In certain areas the burros are being destructive, and in other areas we don't have problems.

I think it is a matter of finding out where the balance is. Can we fit the burro and other animals together?

On the Colorado river these burros will slumber and water with the bighorns. Wells, in his work, showed that in Death Valley much of the competition between burro and bighorn was not for water in the area because of the free-flowing springs. The bighorn depend upon natural springs for water during the summer.

The burros drink these and go a little farther to the river, and they have an adverse effect on the bighorn. We are finding out in some areas that a controlled burro population will be an asset, but I think an uncontrolled burro population can very definitely be a detriment to our native wildlife and to our native forests.

MR. DON ALDRICH: (Montana Wildlife Federation): We have not been in agreement with the program as it has been carried on, and I feel obligated to at least make one comment.

The endangered species in the Montana mountains is the mountain sheep, but it's already gone. The second endangered species is the mule deer, and it is being depleted. The third endangered species is the horse, and it is depleting itself through removal of the vegetation and soil.

I would like to ask Mrs. Johnston if she feels, with the emotion that has been built up to protect these horses, if they are going to be able to control the population. I am afraid that the facility to control it has grown beyond the land manager, and the resource manager. Does she think with this committee which is doing the study they can make recommendations that will keep those animals in numbers compatible with the habitat that's available?

MRS. JOHNSTON: I believe a fair assessment of any solution would necessarily have to await the conclusion of the meetings of these specially appointed wild horse advisory committees. It is comprised of representatives of the various interests involved, all outstanding people in their field.

We have had the one meeting. On the 23rd of March we meet again and on the 24th right in the area. Believe me we have gobs of homework to do. This is not just a passing fancy. We are going into it very deeply, very thoroughly, most conscientiously. Dr. C. Wayne Cook of Colorado State University is our chairman, and we have William Chaney of the Montana Livestock Commission, Mr. Frank Dugal, representing fish and game from Montana, and Dr. Craighead on the animal biology, and me and Mrs. Twine locally here, and the mayor of the town in the vicinity.

Now, you've got to have faith in this committee because it is essential, and hopefully we can contribute something real great after our meetings.

APPRECIATIVE VERSUS CONSUMPTIVE USES OF WILDLIFE REFUGES: STUDIES OF WHO GETS WHAT AND TRENDS IN USE

JOHN C. HENDEE[1]
U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station, Forest Service, Seattle, Washington

The recent report of the Advisory Board on Wildlife Management for the Wildlife Refuge System suggests the lack of a "clear statement of policy or philosophy as to what the Refuge System should be and what are the logical tenets of its future development" (Leopold *et al.*, 1968).

The Board acknowledges the primary objectives of the refuge system as: protecting and perpetuating migratory waterfowl as subjects of hunting and objects of great public interest, preserving rare and endangered species, and providing public hunting. But, in addition, wildlife refuges are suggested as important considerations for outdoor recreation playgrounds and as comprehensive wildlife and natural ecosystems displays. The Board's report clearly raises the question: Since the National Wildlife Refuge System cannot be all things to all people, ". . . in America of the future, what are likely to be the highest social values that the refuges can serve?"

To try to specify the "highest social values that wildlife refuges might serve" would put resource managers in the arbitrary but already too familiar position of specifying what is the best use of a public resource. Our attempts to establish social objectives for public resources too often reflect the inherent biases of our professions and

[1]Recreation research project leader.

organizations as to what values are superior (Reich, 1962; Henning, 1968). On the other hand, who is better qualified to determine resource capabilities and evaluate alternative uses, or combinations thereof, as to their probable consequences? Developing such information would truly redeem professional responsibilities and provide a rational basis for the politically sensitive decisions as to what social values are highest and should be served by the refuge system. The approach assigns technical decisions (what can be) to resource managers but reserves normative decisions (what should be) for political processes (Wagar, 1968).

APPRECIATIVE VERSUS CONSUMPTIVE INTERESTS

Establishing goals and objectives for the National Wildlife Refuge System will require, to some extent, a comparison of "appreciative" or purist interests versus "consumptive" uses such as hunting and fishing. Purists view the natural environment as an object of appreciation, whereas sportsmen are inclined to view nature as something to be used; e.g., production of game and fish. These conflicting perspectives are supported by empirical data as well as by deductive reasoning. In a study of 2,500 recreationists (Hendee, 1967), attitude scores for hunters and fishermen indicated that they were much less inclined to be preservation oriented than other outdoor recreationists and were more likely to hold utilitarian perspectives. Of course, the issue is not clear cut since many hunters are appreciative and some purists hunt. But, as a generalization, the conflicting perspectives of purists and hunters appear valid. Sharply contrasting the two orientations will facilitate comparison of the two types of use.

The established framework pits recreation based on appreciation of the natural environment against consumptive forms of recreation, such as hunting and fishing. Appreciative uses include primitive camping, hiking, photography, nature study and interpretation, vicarious enjoyment of the resource through communication media, and scientific research. Many of them are not in total conflict with hunting and fishing; providing for one use does not always preclude the other. But all are incompatible to some extent, if only in the minds of users; e.g., bird watchers don't like to see birds hunted. And, whereas wildlife can only be shot once with a gun, it can be shot many times with a camera. Future competition between appreciative and consumptive uses of wildlife refuges will become more intense and trade-offs will be increasingly necessary.

SOME BASIC QUESTIONS

Three questions are considered in this paper within the foregoing framework. They are: Who would receive benefits if refuges were managed to emphasize appreciative recreation uses versus hunting and fishing? What intangible benefits would be distributed? To what extent are appreciative uses of natural resources increasing relative to hunting and fishing? Unfortunately, direct information for evaluating the two combinations of use is scarce. However, there have been studies of hunters and fishermen, and data from studies of campers and wilderness visitors reflect valuable information on appreciative uses of natural areas.

Who Would Get Intangible Benefits?

Previous studies document the assertion that all types of outdoor recreation appeal primarily to those in the upper social classes. Outdoor recreationists tend to be highly educated and to work in nonmanual occupations where they earn relatively high incomes. However, recreationists favoring certain types of areas and activities have been found to differ from this norm (Burch and Wenger, 1967; Lucas, 1964b; Hendee, 1967; ORRRC, 1962a; Grey, 1961). Recreationists preferring primitive types of areas such as wilderness tend to be of higher social class than car campers. For example, a recent study of 2,500 campers in the Pacific Northwest indicated (Hendee, 1967) that about 50 percent of the wilderness users came from the top 10 percent of the state's educational distribution; 60 percent came from the top quarter of the state's income distribution, and more than 50 percent from the top quarter of the occupational distribution. Car campers were less extreme, but still from the upper social levels. Car campers who preferred the most intensively developed sites were lowest in social class but still above the general population. Thus, certain types of recreation environments engineered by resource managers attract users with relatively different social characteristics. Recreationists preferring the most natural or undeveloped environments are highest in social class.

We also looked at the characteristics of recreationists preferring different types of activities.[2] We categorized the self-stated activity preferences of recreationists into conceptually related groups based on the implicit meaning of the activity, and compared them by educational levels. Activities based on appreciation of the natural environment, such as viewing scenery, hiking, or photography, were classified as "appreciative." Hunting and fishing were classified as "consumptive" activities. Other categories included "passive free-play," "sociable learning," and "active-expressive" activities. The

[2]Performed in collaboration with Dr. Richard P. Gale, Assistant Professor of Sociology, University of Oregon, and Dr. William R. Catton, Jr., Professor of Sociology, University of Washington.
Our conceptual typology is similar to one developed by Burch (1964, 1965).

results clearly indicated that recreationists preferring activities dependent on appreciation of the natural environment are more highly educated than hunters and fishermen. Nearly three-fourths of those with at least some college preferred appreciative activities. On the other hand, nearly three-fourths of those preferring hunting and fishing had not completed college.

Several studies confirm the fact that hunters and fishermen tend to have less education, lower incomes, and occupational classifications than other outdoor recreationists (ORRRC, 1962a; Peterle, 1961, 1967). A recent study in the Northeast (Bevins *et al.*, 1968) indicated that only 27 percent of the fishermen and 22 percent of the hunters had furthered their education beyond high school but that 52 percent and 59 percent, respectively, were high school graduates. We found similar but slightly higher trends in the Pacific Northwest, the upward bias presumably accounted for by the fact that only *campers* who indicated they also hunted or fished were sampled. Grey (1961) found California hunters, fishermen, campers, nature students, and hikers ranked from lowest to highest, respectively, in terms of education.

Another distinguishing characteristic of hunters and fishermen is their rural background. Over two-thirds of the hunters and fishermen in the Northeast were reported to be rural bred (Bevins *et al.*, 1968), and our study indicated that 75 percent of recreationists who hunted or fished were raised in small towns or rural areas. Several other studies from many parts of the country confirm the rural cultural background of these sportsmen (Maddock *et al.*, 1965; Peterle, 1961, 1967; Folkman, 1963). The rural bias of hunters and fishermen is particularly significant since studies also show that outdoor recreationists preferring primitive or appreciative forms of recreation tend to be urban bred and to reside in urban areas (Catton, 1968; ORRRC, 1962a; Lucas, 1964b; Hendee *et al.*, 1968; Hendee, 1967).

The respective rural versus urban backgrounds of hunters and fishermen and appreciative recreationists seem basic to preferences for these different forms of natural environment use. The urban way of life is not tied to utilization of natural resources the way rural occupations are. Thus, urban conditions permit development of nonutilitarian attitudes toward nature and cultivation of an appreciative perspective. In our study in the Pacific Northwest, recreationists raised in urban areas clearly had the most preservation-oriented and purist philosophies regarding natural resources, whereas those raised in rural or small-town settings tended to have more utilitarian and development-oriented attitudes (Catton, 1967a; Hendee *et al.*, 1968; Hendee *et al.*, 1967).

Studies indicate hunters and fishermen are predominantly male whereas the sex ratio of appreciative recreationists is more nearly balanced (Bureau of Outdoor Recreation, 1967a; Grey, 1961; Folkman, 1963). In addition, minority racial (and perhaps ethnic) groups are underrepresented among both types of recreationists.

Who will benefit should the future use of wildlife refuges be directed toward purist versus sporting uses? The foregoing data give some basis for generalizing. If purist interests are stressed, a highly educated, socially elite segment of society, characteristically raised and now residing in urban areas, will be favored. If management is oriented toward hunting and fishing, a clientele will be served that is more nearly characteristic of the general population in terms of education, occupation, and income but rural in residence or upbringing.

A possible exception to the social class generalizations about consumptive users is the elite group of sportsmen encountered in every study but in insufficient numbers to influence the average. These sportsmen, usually highly educated, affluent urban professionals, secure access to high-quality experiences by their economic and social advantage. Whereas the average hunter may be dying out along with the rural culture upon which participation is based, the elite group may perpetuate itself, particularly where competition for available resources raises the cost of participation beyond the reach of most sportsmen.

Decisions pitting purist versus sporting uses thus contrast social classes and rural versus urban perspectives and values concerning the natural environment. Such generalizations exclude many considerations, but these aspects of natural resource allocation and management have widespread political implications and warrant close attention. Revitalizing rural areas is of great national concern but the one-man, one-vote ruling of the Supreme Court has given urban residents greater political power. The social class issue is also crucial. A leading conservation writer, Michael Frome (1969), recently wrote "I have always considered parks, forests, and Wildlife Refuges as manifestations of a living democracy. Now I suspect they have the same weaknesses as other institutions that need new directions."

What Intangible Benefits?

The recreation experience is a commodity characterized by (1) immediate enjoyment—pleasure incurred before, during, and after participation; (2) long-term physical and psychological benefits to participants—strong bodies and healthy minds; (3) long-term benefits to the nation—happy, more productive citizens (Mack and Myers, 1963) Following are some of the intangible benefits and values attributed in the literature to hunting and appreciative recreation.

Shephard refers (1959) to the reported value of the "stalk" in promoting character, self-reliance, initiative, the primitive satisfaction of instinctive needs, psychological release, and escape from the trammels of society. He then refutes these "Teddy Roosevelt" effects as junk and asserts that the value of hunting is as an "agent of awareness," to confirm man's "continuity with the dynamic life of animal populations. . . ." Leopold (1966) stressed "cultural values in . . . experiences that renew contact with wild things" (such as hunting) and cited a "split rail value" from reenactment of earlier history, value from confrontation with the soil-plant-animal-man food chain, and values arising from exercise of the ethical constraints collectively called sportsmanship. Krutch (1957) indicted killing for pleasure as a despicable way of recreating oneself, but Anthony (1957) in defense of hunting stressed its instinctive basis and character building aspects and said that killing was really a subordinate part of the experience for the true sportsman. Clarke (1958) also found "no blame in the hunter (for killing) as long as his conscience, ruled by respect for nature, governs his action." Leonard (1965) suggested researching the possibility that hunting "sublimates gross animal impulses which might otherwise lead fond husbands and fathers to beat their wives and harass their children." Similar values were also attributed to hunting by a European philosopher (Gasset, 1961) who cited, as benefits of hunting, diversion, pleasure, amusement, challenge, moral restraint, the thrill of chance, satisfaction of basic instincts, escape from the present and fondness for the past, increased alertness, vitality and attentiveness, and various aspects of interaction with nature.

Writing on the subject thus indicates little definitive information about the intangible benefits of hunting but reveals extensive speculation and some defensive reactions to hunting's persistent critics.

The intangible benefits ascribed to appreciative (and other) types of recreation are equally descriptive and lack support by empirical data. The greatest insights into the intangible benefits of appreciative recreation relate to wilderness use where emotional aspects of the experience are thought to be most extreme. After reviewing studies of the appeals of wilderness recreation (ORRRC, 1962a; Bultena and Taves, 1961; Taves *et al.*, 1960; Lucas, 1964d) and in light of our own findings (Hendee *et al.*, 1968), we could only conclude that wilderness visits are primarily motivated by desire to escape from the artificiality of civilized surroundings into natural settings where the necessity for primitive means of existence results in various (but undefined) emotional benefits to the participant (Hendee *et al.*, 1968). One psychiatrist (McKinley, 1963, 1966) suggests that the value of wilderness trips is in the simplified role playing, reduced status seeking, and interpersonal competition during such an experience. "Less psychic energy is expended in fighting down one's buried pain and hostility and more energy can be devoted to an appreciation of the surrounding beauty. The viewer must surrender to the dominance of nature and enjoy the sense of belonging at the center of a much greater whole." McKinley concludes that "People who enjoy it . . . attain a sense of rejuvenation. . . . Commonly, they return with increased vigor, more optimism, and greater tolerance." Another psychiatrist (Menninger, 1948) points out that "Recreation . . . the things a person does for the fun of doing usually with no specific utilitarian or economic motive . . . has a renewing effect psychologically." Stone and Taves (1958) pointed out that wilderness camping extends the opportunity to strengthen primary group relationships, whch are a measure of one's psychological well-being. Foss (1966), in evaluating the results of an ORRRC (1962d) conference of distinguished psychiatrists and physicians on outdoor recreation and mental-physical health, suggests their overall conclusion was that outdoor recreation does provide benefits to physical and mental health but that they could not prove it—the value of recreation to physical and mental health is based on faith, not on evidence.

Available knowledge on the intangible benefits of different types of recreation is thus of little help to resource managers trying to evaluate the social consequences of alternative resource uses. More is needed than just knowing that recreation is good or that it is a medium for satisfying subtle human needs (LaPage, 1963). We have no basis for knowing how important recreation is or if some types of recreation are better then others. However, some observations based on the scanty information available may be of some help.

First, both appreciative recreation and hunting are culturally selective in that they require elaborate preparation to fully capture benefits from the activity. This is implicit in figures indicating the high proportion of adults who began participating during childhood. Second, benefits from both types of use contribute to the general quality of life for the participants. The blue-collar, rural origin of hunters thus indicates that provision for hunting and fishing might contribute more to the quality of life for rural residents than provision for appreciative use would for urban residents. Urbanists are much more likely to come from privileged classes and have other alternatives. This point may be further supported by Pearse (1968) who found that "distant travelers value East Kootenay hunting relatively less than the more proximate hunters." Third, social benefits seem inherent to both types of recreation since they characteristically involve two or more persons participating jointly. These, rather than satisfaction of primitive instincts or the benefits of individual solitude may be the most important values. Finally, the opportunity to increase the intangible benefits of outdoor recreation (whatever they may be) by stimulating understanding through interpretation of the ecosystem may be greater than we think. Interpretation and enhancement of people's fascination with the environment was claimed by one scientist (Wagar, 1968) to be the most underutilized of all wild-land benefits. Perhaps this is reflected in our results of interviews with wilderness visitors, which indicated that 40 percent would pay $2 and 80 percent would pay $1 for an interpretive booklet on the area.

Economists are making headway in measuring the willingness to pay for outdoor recreation but since we seem determined to provide much of the commodity at little cost to the user, our allocations are essentially determined by political rather than market forces. Not that this is entirely bad. The willingness of individual users to pay would underestimate the social worth of the resource due to external benefits (Pearse, 1968) and would limit the distribution of intangible benefits to those with adequate financial means. It is not my intent to depreciate economic approaches to allocation and valuation of recreation resources, for they are important and useful. But, alternative types of recreation that might be provided should also be evaluated as to what types of intangible benefits and values would be generated and who would get them. Unfortunately, studies of intangible or external benefits of recreation are virtually nonexistent although there has been widespread speculation, usually in the form of arguments for specific uses by deeply committed clientele.

Rigorous research is needed to provide some clues to the relative social value of alternative and conflicting types of recreation that might be provided.

Increase in Different Types of Use

One important criterion for determining the highest values to which wildlife refuges might be devoted is the relative social preference for alternative uses.

Hunting as a form of recreation is decreasing, according to studies based on purchase of licenses. Hunters bought 12 million licenses in 1955 (U.S. Fish and Wildlife Services, 1956), 12.1 million in 1960, and 11.6 million in 1965 (U.S. Bureau of Sport Fisheries and Wildlife, 1961, 1966). The ORRRC (1962b) National Recreation Survey revealed much higher participation in these sports but the discrepancies were accounted for by the incidental users. The Bureau of Outdoor Recreation (1967a, 1967b) reports hunting declined 1 percent and fishing increased 1 percent between 1960 and 1965 and that the two sports now involve an average of 12 percent and 30 percent of the population, respectively. The current disposition of hunting is summarized by Peterle (1967): "Hunting . . . will continue to represent a shrinking proportion of those people who seek recreation outdoors. The figures already available indicate not only a proportional decrease in hunting but a decrease significantly correlated with population growth."

This trend is not surprising since hunting seems based on cultural values rural in origin. Migration to urban centers precludes the way of life generating hunting as an expression of values and reduces the opportunity for youth to be introduced to the sport early in life. A recent study concluded that childhood participation was a primary factor in forming interest in hunting and fishing (Bevins *et al.,* 1968) but that in 1965 only one-fourth of the hunters, compared with 60 percent of fishermen, took children along. A decrease in the quality of available hunting and fishing due to population growth is also a probable reason for declining participation.

On the other hand, appreciative types of recreation seem likely to increase. Primitive forms of outdoor recreation, such as wilderness camping, are increasing at much faster rates than the more domesticated version of such activity—car camping. Lucas (1966, 1964c) reports that on the national forests "since 1946 wilderness man-days have increased about seven-fold compared to around a four-fold expansion in other recreation. . . ." His research in the Boundary Waters Canoe Area indicates that boating and canoeing use in the Area are increasing 9 to 10 percent per year (Lucas, 1967). A tenfold increase in use of wilderness by the year 2000 was projected by the Outdoor Recreation Resources Review Commission (1962a), compared with threefold or fourfold increases commonly projected for other outdoor recreation. Much of the dramatic increase in recreation use of the national parks and recent successful passage of legislation to create more parks and wilderness are evidence of increasing awareness and concern of American society for natural environment areas. The Bureau of Outdoor Recreation (1967a, 1967b) reported a 57 percent increase in walking for pleasure from 1960 to 1965, a 35 percent increase in camping, 26 percent increases in hiking and sightseeing, and an 8 percent increase in nature study compared with a 1 percent decrease in hunting and 1 percent increase in fishing.

The opportunity to learn how to enjoy appreciative uses may also lead to increased use. The rapid growth of conservation groups and outdoor clubs is likely to increase skills and interest in appreciative activities. In one study of 1,300 wilderness visitors, we found that 408 users belonged to a total of 208 different groups (Hendee *et al.,* 1968).

Another study (Hendee, 1967) of 2,500 car campers and wilderness visitors revealed memberships in 258 different organizations. At its current rate of growth, the Sierra Club, now 70,000 strong, will double every 3 to 4 years. Leonard (1965) reports that membership in the Audubon Society is growing much faster than hunting license sales. He tells of one wildlife area in Michigan, purchased with hunting license revenues, where nonconsuming uses outnumbered hunting two to one within 15 years.

Two additional types of data provide evidence of impending increases in appreciative recreation rather than hunting and fishing. First are the inferences to be made from the types of people participating in such activities. Present and foreseeable demographic trends are toward more urbanization of the population, further impressive increases in median education, and increased professionalization of the labor force (Catton, 1968b). The increasing educational level of our population is particularly phenomenal. The proportion of college-age people who actually attend college has doubled approximately every 18 years this century (National Science Foundation, 1961). Thus, segments of the population possessing characteristics associated with appreciative use of the natural environments are rapidly increasing. On the other hand, the rural, blue-collar characteristics common to hunters are decreasing.

Second, evidence is accumulating that recreation tastes are quite sensitive to recreation experience gained during youth and, to some extent, to progressive development of tastes and preferences with increasing experience as adults. Increased experience also reportedly leads to primitive recreation preferences.

Such a pattern may result in greater demand for appreciative opportunities as increasing numbers of new visitors and their children are introduced to outdoor recreation and subsequently increase their involvement. Seventy percent of the wilderness visitors contacted in a recent study (Hendee *et al.,* 1968) were introduced to that type of activity in their youth. Burch and Wenger (1967) found that progressively primitive camping styles were related to amount of childhood camping experience. Lucas (1964a) also refers to a study suggesting that as campers gain experience they develop a taste for more primitive experiences. Krutilla (1967) suggests that experience in beginning types of activity, such as car camping, may lead to greater "induced demand for wild, primitive, and wilderness related activities."

Certainly, these studies produce evidence to be considered when the resource manager is establishing priorities and making trade-offs where appreciative and consumptive uses conflict.

CONCLUSION

Competition between appreciative and consumptive uses of wildlife refuges will greatly increase in the years ahead. Participation in appreciative types of recreation is predominantly by highly educated urbanites and is growing rapidly. Hunting and, to a lesser degree, fishing are declining but are participated in by ruralites, more representative of the general population in terms of education and other social class indicators. All types of outdoor recreation, including the foregoing, are underrepresented by minority groups. Studies reflecting benefits accruing to individuals and society from participation in both appreciative and consumptive recreation are of little help, as most works on the subject are descriptive or philosophical. The value of recreation to physical and mental health is accepted on faith but there is little supporting evidence. Rigorous studies are needed to provide resource managers with a better basis for evaluating the social consequences of providing for alternative forms of recreation. In the meantime, policy decisions affecting appreciative and consumptive recreation uses must be based, among other things, on who will benefit and knowledge of participation trends.

LITERATURE CITED

Anthony, Harold E.
1957. The sportsman or the predator: but it's instinctive. Saturday Rev., pp. 9-10, 40. Aug. 17, 1957.

Bevins, Malcolm I., Robert S. Bond, Thomas J. Corcoran, and others
1968. Characteristics of hunters and fishermen in six northeastern states. Univ. Vermont Agr. Exp. Sta. Bull. 656, 76 pp., illus.

Bultena, Gordon L., and Marvin J. Taves
1961. Changing wilderness images and forestry policy. J. Forest. 59: 167-171, illus.

Burch, William R., Jr.
1964. A new look at an old friend—observation as a technique for recreation research. U.S.D.A. Forest Serv. Pacific Northwest Forest & Range Exp. Sta., 19 pp., illus.

__________.
1965. The play world of camping: research into the social meaning of outdoor recreation. Amer. J. Sociol. 70(5): 604-612.

__________ and Wiley D. Wenger, Jr.
1967. The social characteristics of participants in three styles of family camping. Pacific Northwest Forest & Range Exp. Sta. U.S.D.A. Forest Serv. Res. Pap. PNW-48, 30 pp., illus.

Bureau of Outdoor Recreation
1967a. Outdoor recreation trends. U. S. Dep. Int., 25 pp., illus.

__________.
1967b. The 1965 survey of outdoor recreation activities. U. S. Dep. Int., 201 pp. (Unpublished report.)

Catton, William R., Jr.
1967a. Attitudes of car campers and back country visitors. Univ. Wash. Inst. Soc. Res. ISR67-123, 27 pp. (Typewritten.)

__________.
1967b. People who hate crowds don't hate people. (Presented at Fourth Colorado Open Space Program, Estes Park, Colo., Oct. 1, 1967. 29 pp., mimeo.)

__________.
1968. The North Cascades—the proposals as viewed by a sociologist. J. Forest. 66: 540-546, illus.

Clarke, C. H. D.
1958. Autumn thoughts of a hunter. J. Wildl. Manage. 22: 420-427.

Folkman, William S.
1963. Levels and sources of forest fire prevention knowledge of California hunters. U.S.D.A. Forest Serv. Res. Pap. PSW-11, 21 pp.

Foss, Phillip O.
1966. The issues underlying outdoor recreation policy. In Proceedings—national conference on policy issues in outdoor recreation, 1966. Utah State Univ. and Bur. Outdoor Recreation, Washington, D.C. pp. 27-36.

Frome, Michael.
1969. Editorial column. Amer. Forests 75(1): 3, 40.
Gasset, Jose Ortega.
1961. Regarding the hunt. 163 pp. (Unpublished. Translated from German by P. J. Nonnenmacher.)
Grey, David Eugene.
1961. Identification of user groups in forest recreation and determination of the characteristics of such groups. 241 pp. (Unpublished Ph.D. thesis on file at Univ. South. Calif.)
Hendee, John C.
1967. Recreation clientele—the attributes of recreationists preferring different management agencies, car campgrounds, or wilderness in the Pacific Northwest. (Unpublnshed Ph.D. thesis on file at Univ. Wash.)
———, William R. Catton, Larry D. Marlow, and C. Frank Brockman
1968. Wilderness users in the Pacific Northwest—their characteristics, values, and management preferences. Pacific Northwest Forest & Range Exp. Sta. U.S.D.A. Forest Serv. Res. Pap. PNW-61, 92 pp., illus.
———, Thomas H. Steinburn, and William R. Catton, Jr.
1967. Wildernism—the development, dimensions, and use of an attitude scale. (Presented at Nat. Resources Sec. Rural Sociol. Soc. meeting, San Francisco, Aug. 26, 1967.)
Henning, Daniel H.
1968. The politics of natural resources administration. Ann. Reg. Sci. 2(2): 239-248.
Krutch, Joseph Wood.
1957. The sportsman or the predator—a damnable pleasure. Saturday Rev., pp. 8-9, 39-40. Aug. 17, 1957.
Krutilla, John V.
1967. Conservation reconsidered. Amer. Econ. Rev. 57(4): 777-786.
LaPage, Wilbur F.
1963. Some sociological aspects of forest recreation. J. Forest. 61: 32-36.
Leonard, Justin
1965. Moral, ethical, and fiscal aspects of wildlife management. *In* Thirtieth N. Amer. Wildl. & Natur. Resources Conf. Trans., pp. 422-425.
Leopold, A. Starker, Clarence Cottam, Ian McT. Cowan, and others
1968. The National Wildlife Refuge System—report of the advisory committee on wildlife management appointed by Interior Secretary Stewart L. Udall. *In* Thirty-third N. Amer. Wildl. & Natur. Resources Conf. Trans., pp. 30-53.
Leopold, Aldo
1966. A Sand County Almanac, with other essays on conservation from Round River. 269 pp., illus. Oxford Press, New York.
Lucas, Robert C.
1964a. The status of recreation research related to users. Soc. Amer. Forest. Proc. 1963: 127-150.
———.
1964b. The recreational use of the Quetico-Superior area. Lake States Forest Exp. Sta. U.S.D.A. Forest Serv. Res. Pap. LS-8, 52 pp., illus.
———.
1964 c. Trends in use of the Boundary Waters canoe area and the national wilderness use picture. (Presented at Northwest Chapter, Soc. Amer. Forest. meeting, Grand Rapids, Minn., June 12, 1964. 16 pp., mimeo., illus.)
———.
1964d. The recreational capacity of the Quetico-Superior area. Lake States Forest Expt. Sta. U.S.D.A. Forest Serv. Res. Pap. LS-15, 34 pp., illus.
———.
1966. The contribution of environmental research to wilderness policy decisions. J. Social Issues 22(4): 116-126.
———.
1967. The changing recreational use of the Boundary Waters canoe area. N. Central Forest Exp. Sta. U.S.D.A. Forest Serv. Res. Note NC-42, 4 pp.
McKinley, Donald
1963. Why wilderness? Forest Ind. 90(2): 38-39.
———.
1966. Psychology of wilderness. Mazama 48(13): 33-35.
Mack, Ruth P., and Sumner Myers
1963. Outdoor recreation. *In* Measuring benefits of government investments. The Brookings Institute, Washington, D. C. pp. 71-110.
Maddock, Stephen J., George A. Gehrken, and W. Alan Gutherie
1965. Rural male residents' participation in outdoor recreation. U.S.D.A. Forest Serv. Res. Note SE-49, 2 pp.
Menninger, William C.
1948. Recreation and mental health. *In* Recreation and psychiatry. pp. 8-17. [Reprinted by Nat. Recreation Ass., 1960.]
National Science Foundation
1961. Investing in scientific progress, 1961-1970. NSF 61-27: 12.
Outdoor Recreation Resources Review Commission
1962a. Wilderness and recreation; a report on resources, values, and problems. Study Rep. 3, Univ. Calif. Wildland Res. Center, 352 pp., illus.
———.
1962b. National recreation survey. Study Rep. 19, 394 pp., illus.

———.
1962c. Participation in outdoor recreation: factors affecting demand among American adults. Study Rep. 20, 94 pp., illus.

———.
1962d. Trends in American living and outdoor recreation. Study Rep. 22, 257 pp., illus.

Pearse, Peter H.
1968. A new approach to the evaluation of non-priced recreational resources. Land Econ. 44(1): 87-99, illus.

Peterle, Tony J.
1961. The hunter—who is he? *In* Twenty-sixth N. Amer. Wildl. & Natur. Resources Conf. Trans., pp. 254-266.

———.
1967. Characteristics of some Ohio hunters. J. Wildl. Manage. 31: 375-389.

Reich, Charles A.
1962. Bureaucracy and the forests. Center for the Study of Democratic Institutions, Santa Barbara, Calif., 13 pp.

Shepard, Paul, Jr.
1959. A theory of the value of hunting. *In* Twenty-fourth N. Amer. Wildl. & Natur. Resources Conf. Trans., pp. 504-512.

Stone, Gregory P., and Marvin J. Taves.
1958. Camping in the wilderness. *In* Mass leisure, ed. by Eric Larrabee and Ralph Meyersohn. pp. 290-305, illus. Free Press, Glencoe, N. Y.

Taves, Marvin, William Hathaway and Gordon Bultena.
1960. Canoe country vacationers. Minn. Agr. Exp. Sta. Misc. Rep. 39, 28 pp., illus.

U S. Bureau of Sport Fisheries and Wildlife.
1961. National survey of fishing and hunting, 1960. Circ. 120, 73 pp.

———.
1966. National survey of fishing and hunting, 1965. Resource Pub. 27, 76 pp.

U. S. Fish and Wildlife Service.
1956. National survey of fishing and hunting, 1955. Circ. 44, 50 pp.

Wagar, J. Alan.
1968. Non-consumptive uses of the coniferous forests, with special relation to consumptive uses. (Presented at Symposium on coniferous forests of the Northern Rocky Mountains, Univ. Mont., Sept. 19, 1968. 19 pp.)

DISCUSSION

DR. HOWARD WIGHT (Oregon): How can the appreciative user, like the hunter, make a more important contribution to the support of the refuge system?

DR. HENDEE: You accept the idea that one is a free user and one is not. Is that correct?

DR. WIGHT: I'm recognizing the increased use by nonsupport users. Most haven't made much contribution to the development of the system. How can we involve them in support and development of the refuge system?

DR. HENDEE: The appreciative user is represented by a wide variety of conservation groups. I would argue that these groups have generated the values upon which most of the wildlife refuges are sustained. So I would debate the point that they are not supported by appreciative users.

DR. GUSTAV SWANSON (Colorado): One thing that troubles me is the tendency to pit the two groups against each other. It might be more constructive to stress the compatability and need for cooperation among all interested groups. We all know that the shooters, by their preservation of refuge areas, have made an important contribution to waterfowl conservation. It seems to me that we need the cooperation of all interested groups.

DR. HENDEE: Yes. But by sharply contrasting the two types of use, we may more clearly delineate the areas where they do conflict.

CHAIRMAN WILKINS: Thank you Dr. Hendee.

While we wish to provide some provocative papers based on pragmatics, the indistinct state of the art in measuring wildlife values led us to invite several longer papers focusing on conceptual approaches.

THE VALUE OF DIVERSITY

DOUGLAS H. PIMLOTT
Department of Zoology, University of Toronto, Toronto, Ontario

"When on board H.M.S. Beagle as naturalist, I was much struck with certain facts in the distribution of the organic beings inhabiting South America, and in the geological relations of the present to the past inhabitants of that continent. These facts . . . , seemed to throw some light on the origin of species—that mystery of mysteries, as it has been called by one of our greatest philosophers." (Darwin, 1859).

"Man has always been fascinated by the great diversity of organisms which live in the world around him. Many attempts have been made to understand the meaning of this diversity and the causes that bring it about. To many minds this problem possesses an irresistible aesthetic appeal. Inasmuch as scientific inquiry is a form of aesthetic endeavour, biology owes its existence in part to this appeal." (Dobzhandsky, 1951).

"This book is a plea for diversity—for the preservation of natural diversity and for the creation of man-made diversity—in the hope that the prevailing trend toward uniformity can be arrested and the world kept a fit place for the greatest possible human variety." (Dasmann, 1968).

The quotations from Darwin, Dobzhansky and Dasmann serve to indicate that the current upsurge of interest in ecological diversity is just that—an upsurge of interest—not the development of a new concept. Prior to the publication of *The Origin of Species* fascination in the diversity of species was largely an act of marvelling at the remarkable ingenuity of a Creator who had seen fit to put so many different creatures on the earth.

However, in the post-Darwinian era the marvelling changed to questioning—questioning which sought, as Dobzhansky stated it, ". . . to understand the meaning of this diversity and the causes that bring it about." But not until this decade did the word diversity, as an ecological and genetical concept, begin to enter the vocabulary of the wildlife manager or land-use planner. The sudden stirring of interest in diversity among practical people has developed as a result of the realization that technological "progress" is rapidly changing the world and in the process of changing, simplifying and giving both urban and rural environments a similar appearance wherever they occur (Elton, 1958; Dasmann, 1968).

Some dread the process of simplification because they fear the sociological and cultural consequences of a world that produces a profound sense of boredom through the monotony of its appearance and through the limited variety of experiences that can be achieved. Dasmann (1968) seeks to stir world thinking on this side of the question in his recent book, *A Different Kind of Country,* which provided one of the introductory quotations. But although ecologists, along with artists and architects may deplore the influence of simplification of the environment on the aesthetic, cultural and spiritual quality of living, their concern goes much deeper and results from understanding of fundamental ecological processes; the very processes which gave rise to the diversity of nature which stirred Darwin's thoughts and resulted in "the conclusion that man is the codescendant with other species of some ancient, lower, and extinct form, is not in any degree new." The fear about the simplification of environments is rooted in the understanding of diversity because innumerable studies have demonstrated that ecosystems which have a simple fauna contain conditions which result in violent oscillations in animal numbers or in the rapid increase in simple plants (e.g. fungi).

The ecological complications that develop when complex, diverse environments have been replaced with simple, unstructured ones are well illustrated by the problems that have resulted from the establishment of monocultures in the form of conifer plantations, vast acreage planted for wheat, market crops or in fruit orchards. These ecological anomalies have frequently been subject to severe damage as the results of the build-up of insect populations or the spread of fungal diseases.

The fears of ecologists have increased as society has become more and more dependent on this form of land use to meet the increasing demand for food; they have increased as the use of chemicals has intensified the processes of simplifications and, in spilling over, have contributed to the degradation of ecosystems which were far removed from those on which the chemicals were originally placed.

The objectives of this paper are twofold: to discuss the concept of ecological diversity in a way that will highlight some of the conclusions that have been drawn by fundamental ecologists on "the meaning of diversity and the causes which bring it about." Such a discussion is, I consider, necessary to the elucidation of the second objective, to discuss the value of ecological diversity. It should be understood at the outset that this paper is primarily a review paper for neither my education nor my research have particularly equipped me to add much original thinking to the concept of diversity.

THE CONCEPT OF DIVERSITY

Darwin's conclusions about the descent of man resulted from his understanding of the fundamental truth that the variety that occurred in nature was not fortuitous but had resulted from the response of individual organisms to the varied nature of the environments which exist in the world.

It has, however, become evident that the evolutionary response of all animals, for example, has not been of exactly the same nature. Some animals have made a go of things by being generalists and occupying a wide variety of environments; others have specialized and as a result require very specific conditions before they can exist in an area. In eastern North America, the crow and the pileated woodpecker are examples of birds that evolved along wide and narrow lines respectively. As habitats have been changed by human uses it has also become evident that the animals which have taken the narrow road of specialization are those which have been most subject to extinction while the generalists have been prone to increase in numbers, sometimes to very high levels of abundance.

Factors Which Influence Species Diversity:

The observed phenomenon that some areas of the world contain many more species of organisms than others has led to a great deal of speculation about why there is so much variation in the diversity of species. The most common of the hypotheses that have been advanced were discussed in papers by Connell and Orias (1964) and Dunbar (1968).

A popular hypothesis is that the number of species is a direct reflection of the number of niches that are available to be colonized. Since there has been quite intensive study of bird communities it is possible to "document" the point by comparing the large number of species that exist, say, in tropical rain forests as compared with the relatively small number that exist in the simpler (hence fewer niches) community of the boreal forest. It is, however, difficult to argue effectively for this hypothesis without losing the thread of logic. The birds in a tropical rain forest certainly live in a more complex community than those in the boreal forest, but if the number of species of birds depends entirely on the complexity of the forest vegetation, what causes the variation in the complexity of the flora? The soil, or at least the parent material, on which the two floral communities developed does not have nearly the same degree of variability as do the two communities; yet in one area (the tropics) it supports several thousand species of plants while in the other (boreal forest) it supports no more than a few hundred.

A closely related hypothesis suggests that the difference in diversity is a measure of the ecological maturity of environments and that the recurrence of climatic catastrophies (e.g. glaciation) has maintained the northern biota in an immature state (Wallace, 1968; Dunbar, 1960, 1963; Fischer, 1960). Connell and Orias (1964) argued against this hypothesis on the basis of evidence from palaentological studies by Newell (1962) which indicated that although the geographic area occupied by the temperate zone shifted, the shifts did not necessarily result in extinction of species. However, Dunbar (1968) believes that the primary effect to be considered in the ecological-maturity hypothesis is the denudation of large land areas and the setting up of new environmental conditions and not Pleistocene glaciations that caused wide-spread extinctions. He argued that in Arctic situations the evolutionary trend toward complex stable ecosystems works ". . . contrary to ecological adaptation to the highly oscillating environment, which tends to keep the number of species small." However, he accepts the theory that there is a developmnt in all ecosystems toward stability, but he suggested that in polar zones it is ameliorated by the necessity organisms face to make immediate adjustment to the severe environmental oscillations which occur. He summed up the "effects of selection toward two different environmental objectives" as follows:

Environmental oscillation favors selection toward	Stability of ecosystems favors selection toward
1 / High fecundity given by	1 / Low specific fecundity, given partly by
2 / Large body size with many eggs. This is given by	2 / Small body size with small eggs, or large size with large eggs
3 / Slow growth to maturity (slow energy turnover)	3 / Fast growth to maturity (small eggs) or slow growth (large eggs).
4 / Small number of species giving	4 / Large numbers of species giving
5 / Simple ecosystems	5 / Complex ecosystem

Both objectives are favored by
6 / Increased energy capital.

A discussion of fluctuations by Margalef (1968) suggests that he is in agreement with Dunbar on many of the points listed above.

A third hypothesis is based on variation in the ability of plants and animals to withstand the rigors of severe (e.g. polar) environments (Wynne-Edwards, 1952). However, Connell and Orias (1964) argue that rigorness *per se* cannot be the primary factor because if some animals were capable of adapting then others could also have made the adjustment. At this point it would seem valid to question if it is entirely logical to consider hypotheses one after another as if factors of environment and time were not capable of interacting. In considering environments as diverse as those of tropical and polar regions it is possible that climatic stress (rigor) and time (a factor of maturity) are interacting factors.

Dunbar (1968), in fact, suggests the interaction of factors (time and size of niche) in discussing the fourth hypothesis proposed by Klopfer and MacArthur (1960). This hypothesis suggests that ecological niches in the tropics are narrower than those in northern latitudes and result in greater diversity of species in tropical zones. However, there is a feedback mechanism in that the lack of plasticity limits the ability of many tropical species to colonize temperate zones. In a later paper MacArthur (1965) develops the hypothesis in more detail and in his summary states that ". . . total species diversities, from areas composed of many types of habitats, are usually but not always, much greater in the tropics than in temperate regions. This is accomplished by a finer subdivision of habitats (habitat selection) more than by a marked increase in diversity within habitats."

In a very interesting paper, which has been reprinted in several places, Hutchinson (1959) discussed a number of factors which he considered promoted or limited the diversity of species. One paragraph in his paper summed up his conclusion:

> We may, therefore, conclude that the reason there are so many species of animals is at least partly because a complex trophic organization of a community is more stable than a simple one, but that limits are set by the tendency of food chains to shorten or become blurred, by unfavourable physical factors, by space, by the fineness of possible subdivisions of niches, and by those characters of the environmental mosaic which permit a greater diversity of small than of large allied species.

Connell and Orias (1964) described the development of diversity from a model based on Hutchinson's hypothesis that diversity is based on the flow of energy through the food webs that exist in communities (Fig. 1). The model suggests that ". . . positive feedback mechanisms would operate in the early stages of the evolution of a community, ever-increasing its stability, production and diversity. Later, the negative feed-back mechanism would regulate the amount of diversity being maintained, through the instability which is the price of increased specialization and efficiency."

Elton (1946) discussed the relationships which existed within 55 animal and 27 plant communities which he had studied and pointed out that both types contained a high proportion of genera which were represented by only one species. He stated that the difference in species/genus frequencies of small portions of a major habitat and those covering large regions was attributable to the historical effects of composition between species of the same genus. He suggested also that the relatively small number of species represented in community surveys indicates that there is a limit to the numbers of primary consumers that can exist in any given area and that it may represent a state of population competition. Elton's hypothesis that diversity of species is limited by competition was not included in the reviews by Connell and Orias (1964) or Dunbar (1968) that were previously mentioned.

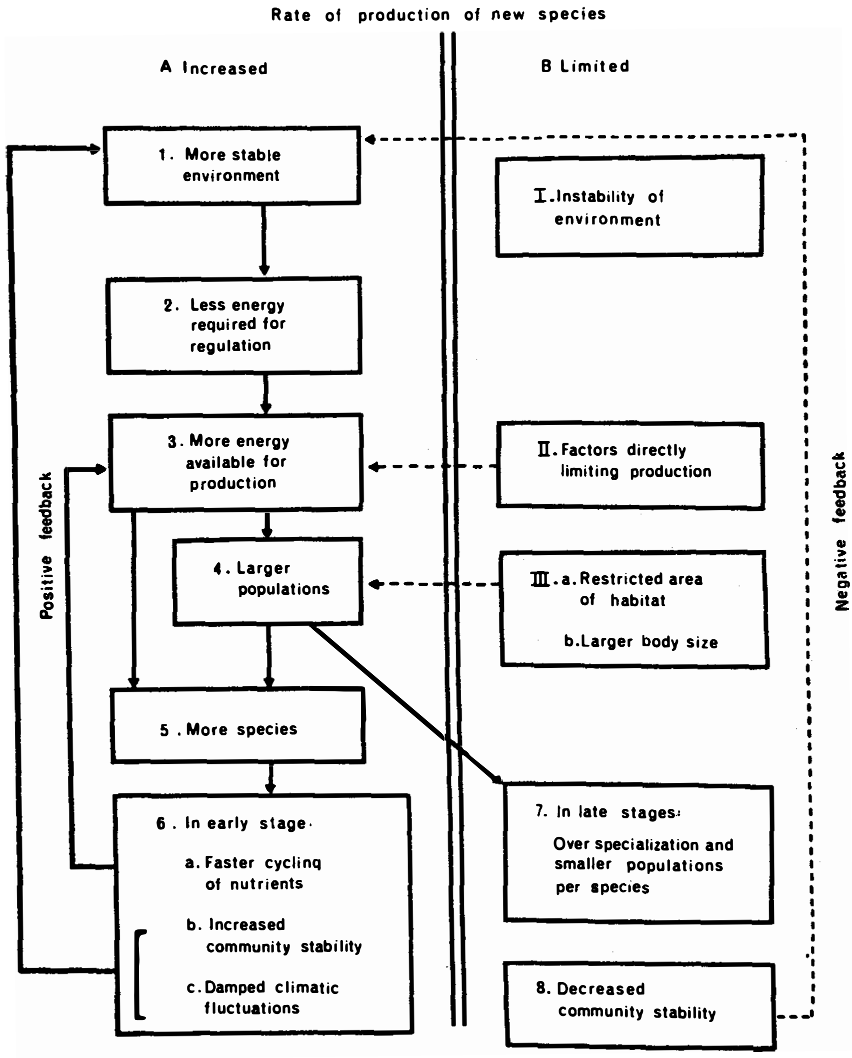


Figure 1.—A model for the production and regulation of species diversity in an ecological system. Solid lines indicate an increase, dashed lines a decrease in the diversity of species. Detailed explanation of model in paper by Connell and Orias (1964).

Diversity and Stability of Populations:

It has been recognized for a long time that in the arctic and boreal forest zones some of the animals such as lemmings, arctic foxes, snowy owls, varying hare and lynx, undergo very marked fluctuations in numbers. The periodicity of the fluctuations is predictable for at least some species. Keith (1962) gives a comprehensive review of the information available for those that appear to have a 10-year cycle of abundance. A number of authors (e.g., Dymond, 1947; MacArthur, 1965) suggested that the fluctuations result from the simplicity of the environment and of trophic links in the existing food webs. In an earlier section I reviewed an hypothesis by Dunbar (1968) which suggests that unstable ecosystems are the consequence of selection toward immediate adjustment to severe oscillation in environmental conditions.

The fact that balance in simple communities is difficult to maintain has also been demonstrated many times by studies of insect populations in monocultures of trees, orchards and food plants. A number of examples are reported in the reviews by Elton (1958) and Pimentel (1961).

Elton (1958) ". . . set out some of the evidence that the balance of relatively simple communities of plants and animals is more easily upset than that of richer ones; that is, more subject to destructive oscillations in populations, especially of animals, and more vulnerable to invasions." He then stated six arguments to show that the complexity of an ecosystem results in greater stability of its constituent populations. His arguments were based on evidence produced by mathematical formulations, laboratory experiments, the historic fact of the invasion of relatively simple island communities, the relative stability of insects in natural communities, and in particular in tropical forests, and finally on the evidence of insect problems that have developed in orchards where pesticides were used indiscriminantly.

Pimentel (1961) showed that insect outbreaks are less likely to occur in mixed stands than in those comprised of a single species. In addition to drawing examples from the literature he gave the results of experiments that he had conducted using cabbage and other varieties of *Brassica oleracea* and several species of Cruciferae. He suggested that diversity relates to community stability in at least three ways:

"First, diversity of host and prey species provides alternate food for parasites and predators and this provides greater stability in these population systems.

"Second, diversity in types of parasitic and predaceous species feeding on one species of herbivore may result in greater stability in these population interactions.

"Third, increased diversity of feeding habits of the species members of a community results in more stability of the organizations."

To sum up, the evidence appears to bear out the general conclusion that the greater the degree of diversity in communities the greater the degree of stability inherent in their constituent populations. Stability appears to be one of the most important values of diversity.

Having drawn a conclusion that is at least close to that stated above, both Elton (1958) and Pimentel (1961) argued against clean cultural practices and for the maintenance of as diverse habitats as possible. They suggested that hedge rows and interspersed habitats provide shelter for parasites and predators which may add to the stability of the populations of insects on nearby crop lands.

Although the general conclusion that diversity results in stability appears to be warranted, there is evidence that in some cases competition among predators may cause interaction which allow prey species to escape from their predators (Turnbull and Chant, 1961; Watt, 1965). The complexities of the question are reviewed in some detail by Watt (1968). It is evident from the case he has developed that much more experimental evidence is needed to clarify the question. Connell and Orias (1964) may have glimpsed some of the truth in suggesting that overspecialization results in decreased stability of the community (Fig. 1).

Diversity and Energy Flow:

Theories of succession and diversity are generally in agreement that the natural trend from immaturity to maturity in ecosystems is toward (i) a stable state in which productivity and respiration are equal ($P/R = 1$) (ii) increased diversity and (iii) a more complete utilization of the energy which enters the system.

In his recent book Watt (1968) points out that data which document that the productivity of diverse natural systems is greater than simpler ones are very sparse. He uses two examples, one which suggests that the biomass of big-game animals in primitive North America and of domestic livestock in 1959-60 were similar (I consider this example as invalid since it draws on estimates made by Seton which were certainly no more than the crudest of guesses) and a second one which compares the production of cattle and wild game on a ranch in Southern Rhodesia (Dasmann, 1964; Matthews, 1962). These studies showed that the maximum production of cattle yielded only 78 percent of the profit that was capable of being produced by a sustained cropping of the 13 game species that were present. Watt (1968) suggested that there were at least four basic reasons why this was the case:

"1. Native wild game have been selected by nature for eons to withstand extreme conditions and endemic hazards in their native habitats.
"2. Native wild game make better use of incident solar energy because of their extreme diversification and specialization.
"3. The great variety of wildlife in Africa make for great community stability.
"4. The habitat is ecologically very 'brittle'."

Watt (1968:71-73) discussed each point in some detail and ended the discussion with the conclusion, "No ecosystem should be altered from its natural state by man in the interests of higher productivity unless it can be conclusively demonstrated by experiments that the alteration really does lead to higher productivity."

It is difficult at least for North America, to discuss terrestrial ecosystems, where a similar situation exists and where value in terms of net profit can be so related. There are many instances where productivity, even if greater, does not necessarily have a direct relationship to yield since a considerable part of the productivity may not have an economic value or at best be of low value. To sum up, it is difficult to present a general argument that diversity has economic value because of better utilization of solar energy for the energy often becomes fixed in forms which are not utilized by humans.

It is possible that the situation may be quite different in the case of aquatic systems such as some of the Great Lakes, but I am not familiar enough with the literature to draw on it for examples. I do, however, recall a simple case presented by Odum (1959) who pointed out that to maximize the yield of fish ponds the diversity of the flora and fauna must be reduced. The example emphasizes again that since productivity and yield are not alway synonymous, questions that pertain to the oconomic values of diversity are not simple ones.

DIVERSITY, WILDLIFE AND AESTHETICS

Habitat Diversity:

The values of habitat diversity as it refers to wildlife management were summed up in a dynamic way by Aldo Leopold in *Game Management* in a chapter entitled "Game Range" (Leopold, 1933). I know of no discussion of the subject that gives a more concise discussion of the values of diversity of habitats to the production and maintenance of wild species. The three paragraphs which introduce the subject and the final one bear quoting directly because of the way Leopold's words set the stage and bring out for the wildlife manager the complexity, and the intellectual challenge of habitat management to produce ecological diversity:

> *What Is Game Range?* When the game manager asks himself whether a given piece of land is suitable for a given species of game, he must realize that he is asking no simple question, but rather he is facing one of the great enigmas of animate nature. An answer good enough for practical purposes is usually easy to get by the simple process of noting whether the species is there already, or whether it occurs on "similar" range nearby. But let him not be cocksure about what is "similar," for this involves the deeper questions of *why* a species occurs in one place and not in another, which is probably the same as why it persists at all. No living man can answer the question fully in even one single instance.
>
> It should be realized, first of all, that the present boundaries of the ranges of our present species constitute a great maze of diversities. If all species boundaries were plotted on a great map of the world, it would look like a wide pavement on a wet morning, after thousands of earthworms had been crawling over it all night, inscribing their irregular tracks.
>
> Secondly, although the boundaries of these present ranges seem so stable to us that we record them in books and maps as fixed facts of nature, they have as a matter of fact undergone continuous change through the ages, each change constituting the response of the species to some change in its environment or in itself.

Then in the final paragraph of the section:

> If the assortment of environmental types in any one locality falls short of being adequate to maintain thrift and welfare, the species shrinks in numbers to what the locality will support. When such shrinkage approaches zero, the locality is lost altogether, and the species withdraws. When such withdrawals become too prevalent, the species becomes extinct.

The message is clear that diversity of habitat is the life blood of the majority of species and the ramifications extend from the subsistence of an individual to the viability of a population and to the survival of species. Using the bobwhite quail and white-tailed deer as primary reference animals, Leopold went on to discuss the need that the majority of species have for an assortment of environmental types during the course of the four seasons. He pointed out that ". . . the service rendered by any environmental type not only varies by species and season but is likely to be contained within a very small fraction of the type." The validity of this statement has been documented many times but in no more relevant way than by the work of the Hammerstrom's (1957) which has been converted into an action plan to maintain a small population of prairie chicken in Wisconsin which is close to being extirpated. The program to maintain prairie chicken in Wisconsin relates the interspersion of habitat types to the mobility of the species and considers the tolerance of the species to variation in composition and interspersion of habitat, all matters which Leopold discussed nearly 40 years ago.

Leopold referred to the need for diversity of habitat in terms of *edgc-effect* and stated that since most species require three or four environmental types on each unit of habitable range ". . . game is a phenomenon of edges." He stated as a law of dispersion that: "The potential density of game of low radius requiring two or more types is, within ordinary limits, proportional to the sum of type peripheries."

The importance of maintaining diversity of habitat types as perhaps the most vital aspect of management for many species, has been discussed in many publications since Leopold wrote *Game Management*. It is referred to both as a general principle in discussing ways and means of modifying the influence of environmental factors and as it specifically relates to the management of species. Because of the difficulty of making a selection which does not simply reflect the contents of one's own library I will refer only to a few of the more commonly known books, for example, *The Deer of North America* (Taylor, 1956); *Our Wildlife Legacy* (Allen, 1954); *Wildlife Biology* (Dasmann, 1964); *Wildlife Management* (Trippensee, 1948; 1953).

I believe that well before the end of this century a great deal of attention will be paid in wildlife programs to the maintenance of habitat diversity for non-game species. Bird watching, for example, is receiving increasing recognition as one of the most interesting avocations and, if it ever was, is certainly no longer limited to "little old ladies in tennis shoes." Interest in the ecological side of natural history, rather than the pursuit of it as a sort of numbers game, has been promoted by publications such as *A Guide to Bird Watching* (Hickey, 1943). The avocation is being recognized as a way in which an understanding of complex environmental interrelationship can be gained in a relatively small area of land. In this respect land-use practises on many areas of public land, which are being managed for timber production or as public hunting areas, will be modified slightly to improve their attractiveness to naturalists. Many managed areas will not require additional modification but will be good just as they are. In *Game Management,* Leopold has a figure (9) which suggests how the interspersion of habitat types could improve an area so that it could support 6 coveys of quail instead of one. The interspersion of types, he proposed, would add considerably to the interest that the area would have for naturalists as well as hunters, because of the number of species that could be found within a limited portion of the area.

The value of diversity to a species extends beyond the admixture of habitat types to the characteristics of the individual habitat type itself. I have thought of this often in recent years as I have strolled through Queen's Park, a small park in the heart of Toronto which is adjacent both to the provincial seat of government and to the University of Toronto where I work.

The northern section of the park consists of appproximately 10 acres and contains an admixture of indigenous and exotic species. The oldest trees in the park are white and red oak; most of the latter are hollow and misshapen and, as they die or are declared a hazard, they are being cut down and replaced by exotic species which are more tolerant of carbon monoxide and sulphur dioxide. The park is a manicured place of asphalt walks, a fountain, benches, strategically placed flower beds and closely mowed lawns. One of the things that makes the park an enjoyable place for the people who use it is the animals that inhabit it. They too are a mixture of native and exotic species. The ones that are likely to be found there at any time of year are gray squirrels, pigeons, starlings and English sparrows.

To the squirrels (the fall population is usually between 25 and 40) the most important element is the oak trees. They provide a very considerable crop of mast and most important of all the "decadent" red oaks are the den trees. Without them, or a substitute, the squirrels would not survive in Queen's Park. One day I talked to a group of landscape architects and tried to draw them out on what they saw in the park, what they would do if they were responsible for its management. I was disappointed to find that they thought only of the land form and of the trees; not one remembered the squirrels in voicing thoughts about what they would do with the park. I urged them to think of the animals as the third dimension, and I argued that the red oak should be maintained as an important component of the park even if it is not as tolerant to an urban environment as some of its exotic counterparts. I argued that the old oaks should be retained as long as they are alive and that perhaps ways might be found to treat the dead stubs so that they could be maintained for use by the squirrels long after the trees have died.

The squirrels add an important element of diversity to Queen's Park and have real value to many of the people who visit it regularly even though their value does not show up in GNP of the country. In other cases, however, where squirrels or other animals are hunted or viewed by naturalists the values are being measured in tangible ways, and some day it will be possible to equate them against the cost of leaving a wolf tree or an overmature red oak in a wood lot because of its importance to wild things.

Diversity and Aesthetics:

It is in terms of values which are most often intangible that the strongest case for the value of diversity can be made. It is on this theme that Dasmann (1968) concentrates in *A Different Kind of Country*. Because it is so thoroughly discussed there, and because in terms of this paper both time and space are limited, I will not talk much about the topic here. However, I would like to state a simple case which suggests that ecological diversity, even that which results from the presence of a single additional organism, can add an important dimension, and hence value, to our lives. I think that the squirrels and pigeons of Queen's Park play such a part in the lives of many people. The Park is not as wild a place as I would prefer it to be, but it is a place many people enjoy; from the first warm days in spring young lovers and old-age pensioners alike make good use of it. Many of those who lunch there, share their food with the animals, and there is one old lady, who buys peanuts by the hundred-weight and comes each day to feed the squirrels or to leave little piles of them at the base of den trees on days when the squirrels are not active.

On several fall mornings I have watched an attractive young lady feeding pigeons as she walked briskly through the park. It is obvious that she does it regularly and enjoys it, for the pigeons swarm around her as she walks and take food directly from her hands; she talks animatedly to them as they flap and fly around her.

A young man who owns a white Alsatian regularly visits the park to give him exercise. The dog delights in chasing the squirrels; I have never seen him catch one, however, it is evident that the activity makes his day, and it is apparent that as long as he is a visitor no squirrel is going to be permitted to lose his affinity for trees or to slow up too much.

Teaching ecology in the heart of a large metropolis can be a textbook type of operation so on a number of occasions I have made a study of *The ecology of the squirrels of Queen's Park* a class assignment. One could say that it is a rather artificial environment for the squirrels. But if so, it really is not important, for they are reproducing, living and dying in Queen's Park; in one way or another all the factors that influenced the squirrels that were living there 300 years ago can be found to apply in the Park today. The diversity added by the squirrels is valuable to us too. We want thought given to maintaining the squirrel population because we think they add a lot to the quality of the Park.

Algonquin Provincial Park in Ontario is 200 miles north of Toronto and is inhabited by deer which are living very close to the northern limit of their range. Because of the stresses that the environment impose they are not nearly as numerous as they are in New York, Pennsylvania or points south. The energy that the deer transfer from plant to animal biomass is often transferred to another trophic level by wolves who prey primarily on deer. Many people go to Algonquin simply because the wolves are there. Those who work at it are sometimes rewarded by hearing a pack howling, by finding a family at a rendezvous site or, in winter, by a day spent tracking a pack which has written a story of its way of doing things on the snow.

Throughout the world people who hunt or who, in other ways, seek to maximize the direct return of the energy of ecosystems to people, kill wolves. In many areas they have succeeded in eliminating them and have achieved their goal at the cost of an important element of the diversity of holarctic environments. But the sense of values change and people who visit Algonquin and other wolf woods of the world are raising more and more questions about the validity of settling a question of tangible versus intangible values in such a final way.

Wolves, coyotes, foxes, goshawks and horned owls are all elements of ecological diversity which will be of greater value to people in the future. I think they, the predators, will be valuable in helping us to come to terms with the total value of diversity in the ecosystems of the world, because their presence causes us to consider the comparative value of tangible and intangible aspects of things that make up our lives.

LITERATURE CITED

Allen, D. L.
1954. Our wildlife legacy. Funk and Wagnalls, New York.

Connell, J. H. and E. Orias
1964. The ecological regulation of species diversity. Am. Nat. 98:399-414.

Darwin, C.
1859. On the origin of species by the means of natural selection. John Murray, London.

Dasmann, R. F.
1964. African game ranching. Macmillan, New York.

Dasmann, R. F.
1968. A different kind of country. Macmillan, New York.

Dobzhansky, T.
1951. Genetics and the origin of species. Columbia Univ. Press, New York.

Dunbar, M. J.
1960. The evolution of stability in marine environments: natural selection at the level of the ecosystem. Amer. Nat. 94:129-136.

Dunbar, M. J.
1963. Ecological adaptation to the glacial climate. Trans Roy. Soc. Canada, I (Ser. 4):433-440.
Dunbar, M. J.
1968. Ecological development in polar regions. Prentice-Hall, Englewood Cliffs, N.J.
Dymond, J. R.
1947. Fluctuations in animal populations with special reference to those of Canada. Trans. Roy. Soc., Canada. XLI:1-34.
Elton, C.
1946. Competition and the structure of ecological communities. J. Anim. Ecol. 15: 54-68.
Elton, C.
1958. The ecology of invasions by animals and plants. Methuen, London.
Fischer, A. G.
1960. Latitudinal variations in organic diversity. Evolution 14:64-81.
Hammerstrom, F. N., Mattson, O. E. and F. Hammerstrom.
1957. A guide to prairie chicken management. Tech. Bull. No. 15, Wis. Cons. Dept., Madison, Wis.
Hickey, J. J.
1943. A guide to bird watching. Garden City Books. New York.
Hutchinson, G. E.
1959. Homage to Santa Rosalia, or, Why are there so many kinds of animals. Am. Nat. 93:145-59.
Klopfer, P. H. and R. H. MacArthur
1960. Niche size and faunal diversity. Am. Nat. 94:293-300.
Leopold, A.
1933. Game management. Scribner's. New York.
MacArthur, R. H.
1965. Patterns of species diversity. Biol. Rev. 40:510-33.
Margalef, R.
1968. Perspectives in ecological theory. Univ. Chicago Press, Chicago.
Matthews, L. H.
1962. A new development in the conservation of African animals. Advan. Sci. 18: 581-585. (Quoted in Watt, 1968).
Newell, N. D.
1962. Paleontological gaps and geochronology. J. Paleontol. 36:592-610.
Odum, E. P.
1959. Fundamentals of Ecology. Saunders. Philadelphia.
Pimental, D.
1961. Species diversity and insect population outbreaks. Ann. Entomol. Soc. Am., 54:76-86.
Taylor, W. P.
1956. The deer of North America. Stockpole and The Wildl. Mgmt. Inst. Harrisburg Washington.
Trippensee, R. E.
1958. Wildlife management Vols. 1 & 2. McGraw-Hill, New York.
Turnbull, A. L. and D. A. Chant
1961. The practice and theory of biological control. Can. J. Zool. 39:697-753.
Wallace, A. R.
1878. Tropical nature and other essays. MacMillan, London. (Quoted in Dunbar, 1968).
Watt, K. E. F.
1965. Community stability and the strategy of biological control. Can. Entomol., 97: 887-895.
Watt, K. E. F.
1968. Ecology and resource management. McGraw-Hill, New York.
Wynne-Edwards, V. C.
1952. Zoology of the Baird Expedition (1950). I. The birds observed in central and southeast Baffin Island. Auk, 69:353-391.

DISCUSSION

MR. MANES: Thank you, Dr. Pimlott. We will vary from the program at this point to permit discussion before the reaction on this paper by Professor McDowell.

This paper has opened up a wide variety of considerations particularly for me.

Dr. Pimlott, since people generally are oriented to economic situations and the Government toward gross national product, does it seem likely that diversity as a value would be accepted in situations where the economic production would be slightly reduced in large areas? To restate it, do you think we can sell diversity as a value to the public?

DR. PIMLOTT: I don't think that we are having too much luck doing that right now, but I suggest that the answer to that question is critical; the answer will determine whether or not we are going to be successful in our occupancy of the world environment for any long period of time. It is around such questions of how we balance technological things with the future of environment that the whole question of society hinges. We can do a lot to encourage people to recognize things that really don't cost us a lot of money. The crux is can we really convince them when it does begin to cost money, particularly when it begins to hold on technology, as it were, for periods of time to give us an opportunity to assess where we're going.

MR. ROLAND CLEMENT (National Audubon Society): It seems definite that we will not succeed in convincing people that we need diversity and that this is a proper cost of living until we have done a good deal more to undermine the false assumptions we have about the importance of current production. One of the means by which we live, for example, is that the consumer is sovereign. This is not so, and those of us who are nature conservationists need to become much more economically oriented and help undermine the false assumptions that now lead people down the wrong path.

MR. CHARLES S. COLLINS (Oregon Wildlife Federation): There is another aspect to this. I think we can bring in economics in some of this diversity. There is economic value to a few wolves in the country. There is economic value, as we heard in another paper, of burros and wild horses. There are economic values in whooping cranes; we have 50 of them left, but they bring in a million dollars a year to Texas alone in tourist trade. We need to stress some of the diversity that is created by predators or some other animals. The American public is developing more and more on this particular line.

DR. WILKINS: We felt that a lucid discussion of the complex conceptual problem covered by these last three papers would be aided by having prepared reactors. They have had only a limited time to review the papers, but we are confident that we will benefit and be stimulated by the comments of the reactor.

As you recognize, when people are asked to react, they react in a variety of ways. Our first reactor is Bob McDowell, professor of wildlife ecology at the University of Connecticut.

In the primary megalopolis of our country, we await his comments on Dr. Pimlott's views of Diversity as a Quality Index.

THE EXTRINSIC VALUE OF DIVERSITY IN AESTHETIC MENSURATION

JAMES H. JENKINS
University of Connecticut, Storrs

Most of us are familiar, perhaps to the point of involvement, with confrontations that erupt from the multiple-use panacea. Little old ladies in tennis shoes do defy the Diesel Juggernauts of highway progress. When said confrontations end in our courts, said protestors usually lose. Progress can be measured by many standards, particularly the dollar, perhaps; beauty but enjoyed.

The beauty of our environment has always inspired the artists among us, gifted in their abilities to express their inner feeelings in visible colors, in audible tones, in tactile sculptured lines. We, who can only appreciate, not create, are grateful to the empathy their talents stimulate within us. (But, really, again in court, how would a painting of a tidal marsh, or the music of MacDowell's "To a Waterfowl" weigh against the dollars represented in the development of a proposed marina or the new town dump?)

The concept of environmental analysis, based upon subjective standards, is not new. The importance of diversity in such analyses has long been understood by the game manager. Leopold (1933) summarized the effect of juxtaposition of habitat types as follows, ". . . game is a phenomenon of edges." On the next page of *Game Management,* he wrote, "The same thing may be stated mathematically as a law of dispersion: The potential density of game of low radius requiring two or more types is, within ordinary limits, proportional to the sum of the type peripheries." Trippensee (1934) "scored" cottontail habitat according to the diversity of its components. Later ecologists have dealt, with ever-increasing sophistication, with other species. But what of the ecologists' analyses of the ecologists' environment? Not expressed solely in terms of Leopold's decimating factors and welfare factors, but expressed according to Leopold's "special factors"—those not vital to a species existence, but essential to its sense of well-being.

Many persons, representing the arts and the sciences, have proposed analyses of the human environment based upon subjective criteria. One of the latest to come to my attention is Sargent's scenery rating system (1966, 1967). Variety, *per se,* is one of two major standards he employs; distance, the other. Certainly, use of the latter may well result in diversity. Furthermore, Sargent's three criteria . . "worthy of note . . ."—depth, width, and intermittency—influence and are influenced by variety.

Shafer and his associates (1969) break through the subjective and offer a technique of environmental analysis based upon a mathematical formula, suitable to computer programming, based, in turn, upon empirical values. In calculating their arbitary parameters of measurement (74-228) of nationwide scenery, diversity is a significant variable.

My colleague, Miklos Gratzer, proposes to take the Shafer team's extrinsic evaluation formula one step farther. He hopes to explain the psychology responsible for these empirical values; in other words, the "why" of the now-predictable aesthetic appreciation environment. To begin with, he has modified the Shafer team's mathematical formula to apply to eastern Connecticut scenery. His parameters are smaller (88-175) due, primarily, to the restriction of intrastate diversity and, due, to a very small degree, to reduced photograph size (8″ x 8″ instead of 8″ x 10″).

Gratzer intends to modify, for faster mensuration, the pupillometric techniques described by Wenger (1967). In brief, dilation (pleasure) and contraction (displeasure) of the eye's pupil are visual criteria.

Gratzer also intends to utilize measurable eye movements (Thomas, 1968) to determine how we "see" our environment. Ink blot and X-ray experiments, described by Thomas, have already demonstrated the importance of the edge-effect (diversity) in the viewing process.

Gratzer will employ both laboratory and field equipment in his investigations into the role of the forest in open space planning in eastern Connecticut.

Perhaps we who are concerned with the conservation of our natural resources will, thanks to the efforts of these current investigators, begin to see "our day in court."

LITERATURE CITED

Leopold, A.
1933. Game management. Charles Scribner's Sons New York. 481 pp.

Sargent, F. O.
1966. Ideas and attitudes—a scenery classification system. Journal of Soil and Water Conservation 21(1):26-27.
1967. Scenery classification. Report 18, Agricultural Experiment Station. University of Vermont, Burlington. 28 pp.

Shafer, E. L. Jr., J. E. Hamilton, Jr., and Elizabeth A. Schmidt
1969. Natural landscape preferences; a predictive model. Journal of Leisure Research 1(1):1-19.

Thomas, E. L.
1968. Movements of the eye. *Scientific American* 219(2):88-95.

Trippensee, R. E.
1934. The biology and management of the cottontail rabbit (*Sylvilagus floridanus mearnsii Allen*). Ph.D. Dissertation, University of Michigan, Ann Arbor. 217 pp.

Wenger, W. D., Jr.
1967. Pupillometrics and aesthetics. Paper presented before the Recreation Researchers' Conference, Syracuse University, Syracuse. 10 pp. (mimeo).

DISCUSSION

DR. WILKINS: While ecologists may strive for measures of quality in biotic communities, surely the primary measure of things has been the monetary unit.

The economists have developed and are developing many approaches to accommodate the allocation problems of nonmarket resources.

Dr. Peter Pearse's paper will help to bring us up to date on promising developments.

Dr. Pearse, perhaps more than any economist has worked with the problem of measuring wildlife values in an economic sense.

DR. PEARSE: Thank you, Mr. Chairman. I must say that as one who has worked in the field of wildlife to a certain extent but cannot consider himself a biologist or ecologist, it is very gratifying to be speaking to this group today.

I must say also that the preceding papers in this session have been ideal in setting the stage for my own paper today. I think the paper by Dr. Pimlott, in particular, illustrated the problem that we are faced with and are trying to quantify in economic terms the value of some of these outdoor recreational pursuits. He mentioned trying to evaluate Queens Park in Toronto. The park involves those attractive trees, and the trees attract squirrels and pigeons. And what is the value of the enjoyment of the attractive young lady who feeds the pigeons? Indeed, what about the enjoyment of Dr. Pimlott who, in turn, watches the young lady?

ECONOMIC EVALUATION OF RECREATIONAL RESOURCES: PROBLEMS AND PROSPECTS

PETER H. PEARSE[1] AND GARY K. BOWDEN[2]
University of British Columbia, Vancouver

The economic analysis typically employed in tackling problems of wildlife and recreational resource management is conspicuous by its paucity and lack of rigour. But the slow progress economists have made in influencing the administrators and managers of these resources is not difficult to explain. Until recently, wildlife and outdoor recreational opportunities could hardly be considered "scarce" in North America because the demand was low relative to their abundant supply. And as long as no pressing economic problems existed, economists were generally content to ignore these uses of natural resources, particularly in view of the awkward analytical problems created by the absence of market prices that economists usually depend on to provide guides to measurements of value.

The managers of these resources, for their part, have not always been enthusiastic about the economist's approach to his problems. Typically trained in the life sciences or professional fields such as forestry, those engaged in fish and wildlife management, parks administration and forest recreation often approach their problems from a different point of view from that of a social scientist. In the extreme, technical experts tend to manage resources for their own sake; and this leads them to pursue purely technological objectives such as maximum sustained yield, full use, absolute standards of quality and so on, regardless of the costs and benefits implied by these

[1] Associate Professor of Economics
[2] Consultant

objectives. Economists are often treated with suspicion, on the belief that they are concerned only with money transactions, and hence are bound to be biased against the subtle, intangible social value of free outdoor pursuits. Indeed, it is sometimes suggested that economics is irrelevant to problems of such "non-economic" activities as recreation.

It cannot be denied that economists have often been guilty of ignoring the value of resources that are not marketed in the usual sense. But, more seriously, they have had only limited success in persuading natural scientists that modern economic techniques, properly applied, can be useful in analysing important problems faced by recreation managers.

During the last decade or so, there has been a new thrust of research effort directed toward finding out the potential relevance of economics to recreational resource management. Managers of recreational resources have felt a growing need to justify, clearly and consistently, their use of resources in the face of the increasing demands of industry which can show benefits in persuasive dollar terms. Yet the rapid increase in demand for outdoor recreational opportunities, coupled with this increasing commercial pressure on the resource base, has sharply increased the economic significance of reserving resources for recreational purposes (Clawson, 1963). Thus the attention of economists has been attracted to the problem. In recent years, research into the economics of outdoor recreation has made a good deal of progress in clarifying the nature of the problems and in disposing of some of the misconceptions that have stood in the way of useful cooperation between economists and natural scientists. While it is obvious that much more work remains to be done, we can now say that we understand the problems and the kind of research required to solve them. It is the purpose of this paper to review briefly the present state of economic research in outdoor recreation and to identify the major outstanding problems.

THE ECONOMIC PROBLEM

Economists see natural resources as part of a society's total stock of capital which, with our labor force and technological knowledge, can be used to enhance the standard of life. Individuals in society have certain preferences which they express in their willingness to pay market prices for goods and services which, in a capitalistic economy, are produced by private entrepreneurs. Producers, in pursuit of profits, will try to meet consumers' demands at lowest possible cost, and hence they can generally be depended upon to use society's resources (land, labor and capital) efficiently. This market system, which we depend upon so much, works well under certain conditions, but its limitations must be recognised. First, there is nothing in the process of free enterprise to ensure that the distribution of income and wealth will be equitable. Equity rests on value judgments, and it would be highly coincidental if someone's concept of a fair distribution of income happened to coincide precisely with that thrown up by the market. Economists, anxious to avoid clouding their analyses with value judgments, have little to say on this problem, but the present involvement of governments in tax and spending programs that redistribute income suggests that society generally is not content with the distribution of income and wealth that results from uncontrolled market forces.

Secondly, the efficiency of the market system depends upon a high degree of competition among producers, in order to maintain efficient production and to ensure that consumer prices do not exceed costs of production. As we all know, however, monopolies and oligopolies exist, and wherever they do we must recognise that some of the economic pressures which force producers to behave in the social interest are lacking.

Thirdly, there are some needs which the private market is incapable of serving. The benefits of national defense, for example, cannot be divided up and sold to individuals, so if any is to be had at all it must be purchased collectively through governments. A variety of the traditional functions of governments, from the provision of legal standards of weights and measures to lighthouses, fall into this category.

Finally, there is a category of goods and services which the private market can provide, but for one reason or another we choose to provide through the public sector. Education, health services and roads could be provided through the market (and at one time or another have been) but are regarded as either inadequately or inefficiently produced by private enterprise. Outdoor recreational opportunities fall into this group in the United States and Canada.

It is important to recognise that our policy of providing recreational opportunities free by governments rests on a purely socio-political decision. There is no technical reason, in most cases, why users could not be charged a fee (either by private entrepreneurs or government agencies) for access to these facilities. It is not the purpose here to question the virtue of our free public outdoor recreation policy, but it is important to recognise the nature of the analytical problem it creates.

Most significantly, it prevents users from registering their evaluation of recreational opportunities through their willingness to pay prices. Hence evaluations of this kind of use of resources must depend on either subjective judgment or complicated analysis of indirect evidence. In addition, the free provision of one kind of benefit, particularly when it involves a sacrifice of alternative kinds of production, benefits some people (recreationists) at the expense of others (taxpayers and commercial enterprises) and so affects the distribution of real income (Seckler, 1966). We must accept, as an assumption, that society regards this redistribution of welfare as desirable. The other problem, that of quantifying the value of the recreation in the absence of market prices, is the one with which the economist may be of some help.

The value of free recreational resources to a society is the benefits gained by those individuals who take advantage of them (we shall refer to exceptions to this statement later). These benefits can be regarded as the amount that the recreationists would be prepared to pay for them, even though they are, in fact, available free. Thus most of the economic research into the value of recreational resources has been directed toward establishing, from indirect evidence, what recreationists would be prepared to pay for the opportunities they usually enjoy free of charge (Clawson and Knetsch, 1966).

METHODS OF APPROACH

With this introduction we can examine the progress that has been made in the economics of outdoor recreation. We assume the goal of managing all resources in a way which will yield the greatest benefit for society collectively, both present and future generations. This means devoting each parcel of resources to that use (or combination of uses) that will generate the greatest excess of benefits over costs, and using public funds in a way that will maximize the values created (Pearse and Bowden, 1968).

PREDICTIONS OF RECREATIONAL USE

In response to the growing pressures on outdoor recreational resources and the need to make decisions about the development of new facilities, models have been developed to predict participation in potential recreation projects. These attempt to predict the consumption of recreation in physical units (such as visitor-days, boating-days, rod-days, etc.) and are usually designed to provide guidelines to priorities among alternative potential projects (Boyet and Tolley, 1966; Ullman and Volk, 1962; ORRRC, 1962). Some of these models are very sophisticated and can be used at both regional and national levels of planning.

Given the need for choosing between alternative projects or sites which will provide more or less identical opportunities and a policy objective of simply meeting recreationists' demands (at zero price)in the most efficient way, these predictive models can serve a useful practical purpose. But they have important limitations. In the first place, there are extremely difficult technical problems in isolating the strength of individual demand-generating factors, especially the influence of available opportunities in stimulating recreation demand (*i.e.*, the interdependence of demand and supply) (Ciriacy-Wantrup, 1960; Bollman, 1967; Pearse, 1968a). Secondly (and more importantly for the present discussion) they provide only estimates of the amount of future use, and no measure of values generated. Since proper planning of resource use requires a comparison of the values generated under alternative forms of development, predictions of participation alone are inadequate. Other methods are required to estimate the values generated at the predicted levels of use.

ANALYSES OF RECREATIONISTS' SPENDING

One approach to the value of recreational activity has been through surveys of recreationists' expenditures. There are many such surveys; the data are fairly easy to obtain, and the data are often very accurate (U.S. Fish and Wildlife Service, 1961; Bowden and Pearse, 1968). However, the significance of these findings is often misinterpreted. The spending of recreationists does not measure the value they derive from the recreation: it measures only their costs. It is equally erroneous to ascribe a value to the recreation equal to the costs of indulging in it as it would be to assume the value of a diamond is equal to the cost of mining it. As mentioned earlier, the benefits of recreational resources are more appropriately regarded as the amount that recreationists would be prepared to pay for them, over and above the actual expenses they incur in travel, supplies and so forth.

Nevertheless, expenditure data are useful in establishing the secondary or indirect benefits of recreational activity. It is these benefits to local merchants, landowners and service establishments that are often used to support proposals for tourist and recreational development. But again the data must be interpreted with care. Certainly the gross spending of visitors is an inaccurate measure of the extent to which a community is made better off, because this ignores the costs of providing recreationists with the goods and services they purchase. The net benefits consist of the difference between gross revenues and the costs incurred by those who service the spenders (Wollman, 1962; Pearse, 1968b).

Thus, while expenditure data, properly analysed, provide useful information about secondary benefits, they do not measure the direct benefits of recreational resources which are enjoyed by recreationists themselves.

ESTIMATES OF WILLINGNESS-TO-PAY

The fundamental issue of the value of recreation to the recreationists themselves has attracted a spate of economic research in recent years. Most of this research effort has aimed at designing methods of establishing the "demand curve" for the recreation, which is the schedule of the amount of recreation that would be purchased at various levels of price. Where the product is free, we know only the quantity demanded at zero price. But most consumers would be prepared to pay some positive price, and a declining number can be expected to be prepared to pay successively higher prices. Thus the demand schedules for most products show an inverse relationship between price and quantity demanded.

The amount a consumer would be prepared to pay for something in excess of the amount he actually does pay, is referred to in economic jargon as "consumer surplus." Where the consumer pays nothing, as in outdoor recreation, all the benefit is a net gain to him in the form of consumer surplus. Thus an estimate of the demand schedule for a recreational opportunity enables calculation of the total consumer surplus, or benefits, enjoyed by all recreationists.

A variety of methods have been suggested for deriving demand schedules (Clawson, 1963; Lerner, 1962; Spargo, 1964). The two most promising lines of approach might be distinguished as "direct" and "indirect" techniques. The "direct" method involves asking the recreationists themselves how much they would be prepared to pay rather than be excluded from the recreation. The array of answers provides the data for the demand schedule (Davis, 1964; Crutchfield, 1962).

The difficulty with this "direct" technique lies in obtaining rational and consistent answers from participants by asking them hypothetical questions. Bias might well result from suspicion about the purpose of the question, emotionalism toward recreational resources, or simply from unwillingness to consider the question carefully. Nevertheless, there is much to be said for the directness and basic simplicity of this approach, and some carefully designed questionnaires, with built-in cross-checks for consistency, have been developed to help mitigate the problem of biased data.

The "indirect" approach is to impute recreationists' willingness-to-pay from observed information about their behavior, particularly their willingness to incur travel costs to get to the recreation site (Brown *et. al.,* 1965; Clawson, 1959; Merewitz, 1966). The basic procedure involves classifying the recreationists according to the distance they travel. The rate of participation (e.g. the number of visits per year per 1,000 population) is then calculated for each distance zone, for which the average cost of travel is also determined. These data are then used to calculate an expression relating participation rates to travel costs, which usually indicates lower participation rates the higher the travel costs. From this, the number of participants that could be expected from a population with a given travel cost under any specified hypothetical toll charge is found by solving the equation for a travel cost equal to the actual cost for this population plus the toll. In this way a demand curve is constructed by adding together the calculated number of participants at different hypothetical tolls for all population groups.

There are serious limitations to this method. Can recreationists be expected to respond to a price in the same way as they do to an equal cash cost of travel? If the recreationists at different distances face quite different alternative opportunities for recreation would they not react differently to a charge? And what if they have different average incomes, or differ in degree of urbanization? Several investigators have suggested ways of dealing with these and other problems (Knetsch, 1963; Pearse, 1968c) and a number of modifications of the indirect technique have been developed.

We are now at the stage where much can be gained by subjecting these methods to repeated tests in different situations. Their inherent weaknesses and biases can often be revealed by applying different techniques to the same case studies (Knetsch and Davis, 1966; Pearse and Laub, forthcoming). Further refinements and experience will help in identifying the most reliable method for each set of circumstances.

SOME ADDITIONAL PROBLEMS

Estimates of the direct value gained by participating recreationists, and of the indirect gains (and losses) that accrue to others as a result of recreationists' spending, yield estimates of the total value of specific recreational facilities. The expected stream of future benefits can be reduced to a current lump-sum value using standard capitalizing techniques. After subtracting costs of development and management, this information can be compared with the net gains expected from alternative uses of the site, or used in conjunction with estimated development costs to evaluate the desirability of public spending on specific projects. If the predicted benefits exceed expected costs, and the net benefit is greater than for any other alternative, the project is economically justified (Pearse and Bowden, 1968).

It must be emphasized, however, that these methods all aim at establishing the *total* value of recreational resources. Often (and perhaps most often) the problem is not whether to have recreation or not, but whether to provide for more or less of it. A typical problem is whether to increase the recreational capacity or quality of an area, at the expense of something else, or to reduce it. What is needed is a criterion for establishing the desirable direction of compromise.

Whenever two or more demands are served on the same parcel of resources, we are faced with a situation of so-called "multiple-use." Multiple use is a hackneyed term which has little operational meaning unless rigorously defined. It tells us nothing about when two or more technically compatible uses *ought* to be served simultaneously, nor, when several demands are to be met, the degree to which one use ought to be sacrificed for another.

Estimates of the total value of benefits generated under each form of use are of no help in dealing with this kind of problem. What is needed are estimates of the gain under one kind of use that can be obtained by marginal sacrifices in other uses. Remarkably little attention has been paid to the basic principles of multiple use, although the theoretical and practical problems they present offer challenging opportunities for interdisciplinary research (Gregory, 1955; Pearse, forthcoming).

The discussion above of direct benefits from recreational resources has centered on the gains to participating recreationists. In certain cases, it may be necessary also to consider benefits to non-participants. It is difficult to substantiate claims that the rest of society benefits from those who participate in outdoor recreation, and these claims are probably overemphasized. But there may be non-participants who value recreational resources, either because they appreciate the option of being able to take advantage of them in the future (Krutilla, 1967) or simply because they believe that the availability of such resources benefits society (Stegner, 1968). These values are exceedingly difficult to quantify. They are probably insignificant in most cases but become important when the resources under consideration are unique, or where decisions affecting them are irreversible (Krutilla, 1968).

CONCLUSION

In the introduction to this paper, it was claimed that some significant progress has been made in establishing the relevance of economics in evaluating recreational resources. Certainly we have come a long way during the last decade in clarifying the conceptual issues involved and in developing general techniques of evaluation. In the past, there has been much confusion over the nature of the product of recreation, which led some, for example, to measure the benefits of sports fishing in terms of fish caught rather than recreation. And sometimes the appropriate magnitudes were improperly identified, such as costs of development used as a measure of benefits. Most of this elementary confusion has been removed. Several approaches to the estimation of the value of recreational resources have been developed, and these probably already yield estimates as reliable as those used frequently in planning other resource projects.

The subtleties of the multiple-use problem have seldom been fully recognised. Here, more than anywhere, analyses depend upon the syncronization of technical and economic data, both categories of which are usually inadequate. There are few areas which offer better opportunities for fruitful cooperation between natural and social scientists than in dealing with the rationalization of conflicting demands on a single resource base.

But the critical problem facing economists remains that of estimating the value of non-priced recreation. The progress hitherto has largely been in clarifying the conceptual problems and in suggesting methodologies. These methods must now be tested, evaluated and refined.

Much of this economic research could be short-cut by actually pricing access to recreational resources. Some economists have advocated such policies not only to provide decision-makers automatically with evaluations of these resources but also as a means of efficiently regulating the intensity of use where congestion threatens the quality of recreation (Scott, 1965). Certainly pricing offers an obvious and easy way of solving many of the problems of recreational resource management; that of rationing use; raising revenues; ensuring that those who benefit bear the cost; as well as establishing values. However, if we are irrevocably wedded to the policy of free access (and for the foreseeable future this appears to be the case) we must nevertheless make estimates of value. For evaluation for planning purposes is quite a separate issue from the policy question of whether users should actually pay.

LITERATURE CITED

Bollman, Frank H.
1967. Economic evaluation of primary benefits from fishing and hunting based on the national surveys of fishing and hunting—a progress report. Paper prepared for the Conference on the Demand for Fishing, Hunting, and Other Outdoor Recreation Activities, sponsored by the Bureau of Sport Fisheries and Wildlife, Washington, D.C., February 27-28, 1967.

Bowden, G. and Pearse, P. H.
1968. Non-resident big game hunting and the guiding industry in British Columbia. Study Report No. 2 on the Economics of Wildlife and Recreation. Department of Recreation and Conservation, Victoria, B.C.

Boyet, Wayne E. and George S. Tolley
1966. Recreation projection based on demand analysis. Journal of Farm Economics 48(2):984-1001.

Brown, William G., Ajmer Singh and Emery N. Castle
1965. Net economic value of the Oregon salmon steelhead sport fishery. Journal of Wildlife Management 29(2):266-279.

Ciriacy-Wantrup, S. V.
1960. Conceptual problems in projecting the demand for land and water. In Harold G. Halcrow et al. Modern Land Policy: Papers of the Land Economics Institute. University of Illinois Press, Urbana.
Clawson, Marion
1959. Methods of measuring the demand for and value of outdoor recreation. Resources for the Future Inc., Reprint No. 10. Washington, D.C.
Clawson, Marion
1963. Land and water for recreation. Resources for the Future Inc., Washington, D.C.
Clawson, Marion, and Jack L. Knetsch
1966. Economics of outdoor recreation. Johns Hopkins Press, Baltimore.
Crutchfield, James A.
1962. Valuation of fishery resources. Land Economics 38(2):145-154.
Davis, Robert K.
1964. The value of big game hunting in a private forest. Transactions Twenty-Ninth North American Wildlife and Natural Resources Conference. P. 393-403.
Gregory, G. Robinson
1955. An economic approach to multiple use. Forest Science 1(1):6-13.
Knetsch, Jack L.
1963. Outdoor recreation demands and benefits. Land Economics 39(4):387-396.
Knetsch, Jack L. and Robert K. Davis
1966. Comparisons of methods for recreation evaluation. In Kneese and Smith eds. Water Research. Johns Hopkins Press, Baltimore.
Krutilla, John V.
1967. Conservation reconsidered. The American Economic Review 67(4): 777-786.
Krutilla, John V.
1968. Balancing extractive industries with wildlife habitat. Transactions of the North American Wildlife and Natural Resources Conference. 33:119-130.
Lerner, Lionel J.
1962. Quantitative indices of recreational values. Water Resources and Economic Development of the West, Report No. 11, Committee on the Economics of Water Resource Development of the Western Agricultural Economics Research Council. San Francisco.
Merewitz, Leonard
1966. Recreational benefits of water resource development. Water Resources Research 2(4):625-639.
Outdoor Recreation Resources Review Commission.
1962. Economic studies of outdoor recreation, Study Report No. 24. U.S. Government Printing Office, Washington, D.C.
Outdoor Recreation Resources Review Commission
1962. Prospective demand for outdoor recreation, Study Report No. 26. U.S. Government Printing Office, Washington, D.C.
Pearse, Peter H. *et al.*
1968a. Forecasting the demands for water. Queen's Printer, Ottawa.
Pearse, Peter H.
1968b. An economic evaluation of non-resident hunting and guiding in the East Kootenay. Canadian Journal of Agricultural Economics 16(2):100-111.
Pearse, Peter H.
1968c. A new approach to the evaluation of non-priced recreational resources. Land Economics 44(1):87-99.
Pearse, Peter H.
forthcoming. An approach to the theory of multiple use: the case of recreation *versus* agriculture. Forthcoming in the Natural Resources Journal.
Pearse, Peter H. and Gary Bowden
1968. Economic evaluation of widllife development projects through benefit-cost analysis. Paper prepared for the Thirty-Second Federal-Provincial Wildlife Conference, Whitehorse, Y.T., July 9-11, 1968.
Pearse, Peter H. and Michael E. Laub
forthcoming. The value of the Kootenay Lake sport fishery: An Econimic Analysis. Forthcoming Study Report No. 3 on the Economics of Wildlife and Recreation. Department of Recreation and Conservation, Victoria, B.C.
Scott, Anthony D.
1965. The valuation of game resources: Some theoretical aspects. Canadian Fisheries Reports, Report No. 4. Department of Fisheries of Canada, Ottawa.
Seckler, David W.
1966. On the uses and abuses of economic science in evaluating public outdoor recreation. Land Economics 42(4):485-494.
Spargo, R. A.
1964. Evaluation of sport fisheries: An experiment in methods (unpublished mimeograph). Economics Service, Department of Fisheries, Ottawa.
Stegner, Wallace
1968. The meaning of wilderness in American civilization. In The American Environment: Readings in the History of Conservation (Roderick Nash, Ed.). Addison-Wesley Publishing Co., Reading, Mass.
Ullman, Edward L. and Donald J. Volk
1962. An operational model for predicting reservoir attendance and benefits: Implications of a location approach to water recreation. Papers of the Michigan Academy of Science Vol. 47:473-84.

U.S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife
1965. 1965 National survey of fishing and hunting. Resource Publication 27. U.S. Government Printing Office, Washington, D.C.
Wollman, Nathaniel, *et al.*
1962. The value of water in alternative uses. The University of New Mexcio Press, Albuquerque.

DISCUSSION

DR. WILKINS: The reactor for this paper is Dr. Robert Weeden, who attained his Ph.D. at the University of British Columbia before Dr. Pearse joined the faculty.

Dr. Weeden is in charge of the Alaska Fish and Game Department investigations on waterfowl, fur animals and other game. He recently has had the added task of evaluating some of that state's wildlife.

ECONOMIC EVALUATION OF RECREATIONAL RESOURCES: PROBLEMS AND PROSPECTS—A REACTION[1]

R. B. WEEDEN

Alaska Department of Fish and Game, Fairbanks

For my own convenience in preparing this discussion I summarized Pearse and Bowden's paper as follows:

> The social value of recreation is the sum of benefits gained by recreationists. These benefits could be measured by the amount of money participants would be willing to pay. Because governments usually provide recreation opportunities free to users, the normal market transactions that measure value are absent. A fee system would make the job of the economic researcher much easier. Presently economists can either ask people directly what they would pay for a specific recreational opportunity, or they can compare participation with distance between home and recreation area and construct a demand curve. Neither method is well enough developed to be widely applicable. If willingness to pay could be quantified, however, the information would help administrators decide on priorities among competing resource users.

The key points I will comment on are (1) that "willingness to pay" is an adequate measure of economic benefits of outdoor recreation (and, secondarily, that fees at public recreation areas would provide data to show willingness to pay), and (2) that economic benefits, so measured, provide managers with a basis for decisions.

In my opinion there may be considerable confusion between "willingness" and "ability" to pay. I agree with Pearse and Bowden that if economists could quantify willingness to pay, we would have a good measure of the extent of anticipated benefits to each individual,

[1]Paper by Pearse and Bowden

and (in sum) to society. But the number of dollars a person would say he would be willing to pay would result from the combining of his *motivation* (degree of expected benefit) and his *ability* to pay. A pauper living next to a park with an entrance fee might be so strongly motivated that he would climb the wall to get in, yet wouldn't be "willing" (able) to pay a dollar at the turnstile. A millionaire, on the other hand, might be willing to pay hundreds of dollars for the chance to get into the park if it were the only place he could go for outdoor recreation.

I also suggest that fee charges by governments would not give economists the data they need for calculating willingness to pay. The United States Government has had user fee charges at certain outdoor recreation areas for years, particularly since passage of the Land and Water Conservation Fund Act. However, the fees were not set in any way remotely resembling market conditions, in consideration of supply and demand. Rather, they were established to raise a certain amount of money for a certain purpose, unrelated to users' willingness to pay. Perhaps through experimental raising and lowering of the fees we could gauge the users' ability or willingness to pay *given the availability of alternate areas with different (or no) charges.* To my knowledge this has not been done.

I feel constrained to raise the rather tired issue of so-called "intangible" values. It should be clear to everyone that money is basically a poor measure of value—that is, to fundamental values of existence and enjoyment of life. The price of a thoughtful book, for example, is some measure of the supply of the book and the demand for it, but the ideas it contains are beyond pricing. In the case of natural outdoor recreation areas, society may be tempted to calculate costs and benefits, in dollar terms, of strip-mining for coal versus establishment of a park. This is reasonable while the supply of potential recreation areas is able to meet demand. But can economists measure what individuals lose when the demand has outrun supply—and very likely even destroyed it, in the case of wild areas?

The main question I would raise concerns the usefulness of economic yardsticks in establishing priorities of resource allocation. The impression one gets is that Pearse and Bowden think a detailed knowledge of dollar worth of a piece of ground for cellulose and birdwatching would equip an administrator to determine in what direction lies the greatest benefit to society. In our democratic society, however, it is the people whose welfare is at issue. A professional resource administrator is more or less capable of saying what is good for a resource but is no better equipped to say what is good for people than anyone else. His main function is to provide the people with alternatives of management and their consequences, and to carry out their decision. As yet we have no better process than effective public review and politics for insuring the best conformity of needs and programs.

I suggest that measuring wildlife or other renewable resource values in monetary terms is just one of the games we play so that our favorite resource can compete successfully for budget and space. For example, the Bureau of Land Management in Alaska is trying to plan broad management goals on tens of millions of acres in the public domain. When one potential beneficiary says," If you open this area to free mineral development, $200,000 of immediate benefits will accrue," it is very nice (if you happen to be a recreation planner) to be able to say that turning the area into a tourist center will yield $201,000 to the local economy. Actually, both statements should be suspect—as will usually be clear from the escalation of estimates in the ensuing competition.

As a wildlife biologist I can see certain situations in which present economic techniques are of very little help in resource management. One is in the effort to save species from extinction. This comes as close as anything I can think of to "conservation or conservation's sake." An economist might be able to define for us how much we are able to spend on a rare species, but I doubt that he could adequately measure the cost of extinction or the benefits of being.

The other situation is one with which we work daily in the north: the use of wild game for food. To put it simply, hundreds of people survive only when they can shoot enough caribou or walrus, or net enough fish. What is the dollar value of the game? It might be argued that the worth of the wild game is equivalent to the cost of supplying these people with shipments of so much protein, so much vitamin, etc. I reject this, however, since massive and complete welfare, though technically feasible, is, in my view, socially intolerable.

A final thought: Preserving nature does not have to be justified on economic grounds. The only excuse for not preserving nature is when real shortages of material resources threaten our survival at some reasonable level of comfort beyond bare existence. (And nature, of course, is one of the amenities contributing to this distance we live beyond the cliff's edge.) When these shortages loom we cannot take it for granted that nature must go. The cause of the shortage is too many people. The solution I prefer is effective population control, not progressive destruction of the environment. It seems to me that the two main challenges to economists today are to examine the myth of perpetual growth in production and consumption, and to begin examining the utility of goods and services to society so that distinctions can be made between the frivolous and the essential.

In summary, there are facets of resource management activity in which knowledge of dollar values is useful. These usually are when a middle-level planner is trying to decide how to allocate land and other resources under his jurisdiction among competing users. When it comes to basic questions about how people will benefit or lose under alternate management programs, or about what people want, economic estimates based on market or simulated market transactions are of scarcely any value at all.

DISCUSSION

MR. ROLAND CLEMENT (National Audubon Society):

May I ask Dr. Pearse to comment briefly on the opportunity-cost approach of evaluating some of these resources? I can make more money editing on weekends, for example, than I get paid during the week. The question is shall I go fishing or shall I edit somebody else's work. There's a sacrifice involved here, and is there a way of working this into the economic formula?

DR. PEARSE: Yes, I think that the whole process of evaluation involves this. Your evaluation of weekend fishing is precisely what you're prepared to give up to go fishing. If we can get data to figure out how much people forego for a weekend's fishing and get that information from all the fishermen, we've got exactly the information that we need to assert the value of that recreational opportunity.

DR. DONALD D. J. ZINN (President, the National Wildlife Federation): I have some support for Dr. Pearse, especially with regard to the question of willingness.

Very recently a survey by the Gallop Poll was authorized by the National Wildlife Federation, and a report was just given by Mr. George Gallop, Jr. at our meeting two days ago concerning attitudes of people toward natural resource conservation in this country. One of the questions asked was how many people were interested in paying for recreational opportunities. In answer, more than 60 percent of the people—this was the usual type of cross section that the Gallop Poll covers—indicated that they were willing, not only willing to pay, but willing to pay what Mr. Gallop listed as a moderate fee that is, upwards of $10, for this type of recreational opportunity. So while this is certainly not a definite scientific statement, it certainly is a sign in the wind and a very hopeful one.

DR. KENNETH DIEM (University of Wyoming):

One problem that we run into with regard to economics, is separating what is demand and what is subterfuge to save one's selfish interests.

In Wyoming where we have a large segment of resources and a low human population, we have had some rather interesting experiences whereby we have solicited money to maintain leases. Now, this is to preserve a resource; in this case it happened to be for fishing through public access. The question that comes up is who is paying for what purpose? Economically this is difficult to filter out and reflects on Dr. Weeden's concern. We find people for instance, contributing $5 very readily for brown trout fishing to keep what they consider the trash bait fishermen off of their favorite trout stream.

Something that economists have not recognized is how willing are people to stratify quality by paying for the other guy not to be there. Wilderness users versus the pickup camper crowd; water skiier versus the fly fisherman and the trolling fisherman. Do economists have this answer? Has this been considered? I think it's a real problem. Nine-tenths of the complexity arises from people being willing not to pay so much for their own recreation as for the other guy not to be there.

DR. JOHN KRUTILLA (Resources for the Future): As biologists are concerned with biological diversity, economists are concerned with diversity of opportunity to indulge a whole range of tastes.

The previous question referred to the exclusion of trash fishermen, by those who like brown trout, but this is what the economic process does all the time. When you buy or bid for something that is of value to you, you may exclude someone else from using the resource in another way. This provides some means of providing diversity in the recreational area. Biologists are very keen to claim the biological field as a value, I would say.

DR. WILKINS: If quality lies in people, it is clearly influenced by culture. To suggest this important point and to emphasize the important role quantity continues to play, our next speaker relates such a topic to a culture quite different from ours.

WILDLIFE VALUES—QUANTITY AND QUALITY IN SOUTH AFRICA

JAMES H. JENKINS[1]
University of Georgia, Athens

It is common, in the right spots, to observe in a day of game watching up to 6,000 head of big game constituting 20 of the 50 species which can be found in southern Africa. Game watchers there fill the same ecological niche as bird watchers in Europe and America. Wildlife values are high both quantitatively and qualitatively in selected but widespread areas of South and East Africa.

Strictly speaking, southern Africa is usually considered to be that part of the continent south of the Zambesi River. This area encompasses a wide spectrum of ethnic cultures and living standards ranging from bare tribal subsistence to raucous industrial growth reminding one of the bustling "progress" of Chicago. This discussion will concern The Republic of South Africa and the territory which it administers, South West Africa. This is a thoroughly modern society with a conservation movement and history with strong parallels to the U. S. It is hoped that a few values and attitudes can be brought out that are not typically encountered in our culture. The author was privileged to teach and help set up a graduate program in the Zoology Department of the University of Pretoria in The Republic of South Africa in 1966. This was part of a five-year program in which professors from the U. S. were invited and extended teaching and research contracts.

HISTORICAL

Dr. Durward L. Allen (1954) has pointed out that every area should have a wildlife historian. We learn much about ecology and management from the past record. South Africa has had literally around twenty such historians, and these chronicles have been popularized recently in a "best seller" form by Alan Cattrick (1959). Although Cape Town was settled in 1652, most of the interior was not opened up until the famous great trek with covered wagons and oxen

[1] Professor of Wildlife Management, School of Forest Resources

in 1835-43. The "taming" of South Africa was characterized by widespread wildlife destruction, mostly with firearms, just as the buffalo was essentially wiped out of the West. After most of the larger and admittedly dangerous wildlife was eliminated, parks were established around 1900. Game and fish departments were formed in each of the four provinces and the territory in the third and fourth decades of the present century. The National Parks Board is a federal agency having jurisdiction over several large and spectacular parks, such as the Kruger National Park and the Kalahari Gemsbok Park. There is no federal agency comparable to our U.S. Fish and Wildlife Service.

The progressive South West Africa Department of Nature Conservation and Tourism administers the Etosha Game Park, a 22,000-square mile area, in the northwest part of South West Africa. This is reported to be the largest park in the world. I was the guest of this department and the Natal Province Game Department. However, I worked closest in many ways with the Transvaal Game and Fish Department (Transvaal Nature Conservation Branch under the direction of the late Mr. Theunis J. Steyn).

All of the above-mentioned departments were organized similarly to the British civil service, and the scientific quality of research was uniformally high.

CONSUMER USE

Big-game hunting in South Africa is limited at present for both the resident and non-resident hunter. It is increasing each year on private ranches as they build back, and on a wide variety of miscellaneous wild lands under the control of the game departments. The first job of the game departments has been to preserve what they could through enforcement, setting up of refuges, and restocking—exactly the same techniques that we have employed successfully in this country. Big-game hunting is available in South West Africa and will increase. It is, of course, readily available in the adjacent wild undeveloped reaches of Botswana, Angola, and Mozambique.

The capture and restocking work entails various mechanical means and some use of the modern drug automatic projectile-syringe technique (Crockford *et al.*, 1958; Harthoorn and Bligh, 1965) or some variant (Van Niekerk and Pienaar, 1962).

Game-bird hunting is not considered to be a great sport in areas settled largely by the Afrikaans farmers (Boers) but is highly regarded in Natal and in East Africa where the Europeans are of more direct English descent. By any standards, the wing shooting in Africa is superb (sand grouse, guinea fowl, and a variety of francolins). There has been a recent increase in interest in game-bird management by the South African game departments, however.

Fishing for tilapia and carp are widely indulged in in spite of the wide prevalence of bilharzia, a schistosome fluke, in the waters which can penetrate the intact skin and cause degeneration of the liver. Treatment of bilharzia still leaves something to be desired. This disease is an occupational disease for the fisheries workers in all of East and South Africa. The Nature Conservation Branch is doing research on this serious problem in cooperation with the health authorities. The Branch also funds a fresh-water fish experimental station, whose chief function is to develop cheap sources of fish protein as a crop. There are several fish hatcheries for tilapia and rainbow trout. Rainbow trout fishing is reasonably common near Pretoria, which is somewhat surprising since the latitude is 26°, the same as Miami, Florida, in the northern hemisphere. Of course, the trout thrive at the higher altitudes (generally above 5,000 feet).

NON-CONSUMER WILDLIFE ACTIVITIES

Game watching has a wide appeal to different stratas of society and is essentially a universal activity. It is commonplace for families to drive 200 or more miles in order to spend a weekend watching the animals in Kruger or several other well known parks. It is such a universal sport that it is sometimes necessary to book reservations at a park rest camp a year in advance. Game watching and the availability of miles of wild country and scenery in southern Africa has spurred interest in trailer camping, now common and widespread.

Special efforts have been made in the parks to provide blinds and protected facilities for photography since the opportunities are unsurpassed. Game watching in addition to having a universal appeal is not difficult so far as technical identification is concerned. Wankie National Park in Rhodesia has as much variety in game mammals as any park in the world, with 50 recorded species of game. At Etosha Game Park it has been possible to record 20 species, and 6,000 individual head of big game in a day. More than 1,500 head have been recorded in a day at a single water hole. With this widespread interest it is little wonder that there is determined opposition to attempts by parks administrators and biologists to cut down on the numbers of some species. Much of the Kruger is obviously heavily overgrazed and parts of it at some seasons seems to be turning into a game-produced desert. The 8,000-square mile area is known to have around 8,000 elephants and a cropping scheme which was overdue is in progress. Cape buffalo and impala are also present in excessive numbers. Opposition to game reduction has been vociferous and the program has had to proceed judiciously. All "culling" is done by park personnel, and park administrators have told me that they could not consider safari sport hunting even in completely inaccessible and closed areas of the parks. Trophy hunting as a source of needed revenue and as good management is being considered in some parks in East Africa. Another sign of the high interest in wildlife and its conservation is evidenced by the fact that, as park warden positions become available, there are often dozens of applicants for these jobs, including a surprising number of people trained in other more lucrative professions.

The parks department has an active and quality research program. They attempt to maintain natural conditions by limiting roads and curving those that are necessary. There has been controversy about whether hard-surfaced roads ruin the aesthetics of a park and in general they have been avoided. But the alternative is stifling dust and heat which would appear to be less preferable. People are not allowed out of cars except in fenced or special areas. Most of the rest camps have curfew hours at dusk and dawn with stiff penalties for being out after curfew, for driving on secondary roads, and for stepping out of vehicles. These rules are not uncommon over much of Africa where large carnivores are abundant.

WILDLIFE MANAGEMENT

As in the U. S., the first job has been to stop the destruction and to build back the stocks of depleted or extirpated species. This process is now well along through the establishment of a system of nature preserves or wildlife management areas on which some controlled harvest will be allowed and encouraged.

The restocking program has for us an exotic ring. Riney and Kettitz (1964) have reviewed this program in depth. Animals which have been reestablished in various parts of southern Africa include: blesbok, springbok, blue wildebeest, black wildebeest, zebra, eland, impala, giraffe, kudu, steenbok, duiker, ostrich, tsesseba, nyala, and red hartebeest. An outstanding achievement has been the highly successful saving of the southern white rhino. By 1900 it had been exterminated throughout its range except for the relatively tiny area of the Umfolozi Game Reserve near the Indian Ocean in Zululand in Natal Province. Since 1961 a total of 499 (Player, 1967) have been captured using the projectile syringe gun for distribution to other game reserves in southern Africa. Harthoorn (1962) carried out the pioneering drug experimental work making this work possible. At present, this large incongruous creature seems abundant and widespread enough to be out of danger of extinction.

Steyn (1958) has discussed the overall accomplishments of wildlife management in the Transvaal in protection, restoration, fisheries research, flora protection, and black-backed jackal control. Kettlitz (1962) of the Transvaal Nature Conservation Branch has discussed game ranching in conjunction with cattle ranching. Van Zyl (1962) determined some meat production potentials of the eland. Game cropping, combined as secondary to cattle ranching, is common and widespread over South Africa. The author worked with the field capture team of the Transvaal in giraffe capture. These animals are requested for restocking by cattle ranchers. In a sense, they are the classic species of a new concept in conservation. They are gentle animals and in much demand. They feed on the tops of the acacia and other trees so they hardly compete with cattle at all. They are an aesthetic addition to any ranch, a source of much rich protein, and their hides have utility in making oxen harness. In 1966, although the game department was catching several dozen each season, they were three years behind on requests for brood-stock animals. The game department has a deep interest in game ranching and had posters stating, "Remember that game will thrive where cattle cannot survive."

The late Mr. T. J. Steyn (1966), director of the Nature Conservation Branch of the Transvaal, was thoroughly convinced that game ranching as a separate, distinct industry probably has more future: (1) in a developing nation since lack of transport and refrigeration make meat handling a problem, but dried meat (biltong) is a common staple; (2) where cattle diseases are still a problem and; (3)in arid desert areas where cattle ranching is impractical. Taylor (1969) has shown that both the eland and oryx have special adaptations whereby they can get along indefinitely without drinking water. Game ranching as a separate entity is making some progress in Rhodesia. In 1964 there were 33 game ranches with 14 as income producers. Commercial utilization of large mammals, usually in combination with conventional ranching, involved over 3,000 farms in the Transvaal in 1963 (Riney and Kettlitz, 1964) and has increased since. Wild game meat (venison) sold under regulation is common in the butcher shops in South Africa. More and more ranches are selling hunting privileges.

Veld management, as in our own plains country, becomes a problem in prevention of overuse. Drouths are usually blamed for deteriorating grass cover. Game managers are busy putting in exclosures, transects, and measuring range trends. It is well recognized that game does not "impoverish" the veld to the same extent as domesticated animals even in poor years (Kettlitz, 1962). The African has a strong tendency through excessive grazing and fire to reduce cover on his areas to a bare pavement desert. The European rancher on the other hand, through overgrazing and fire protection, converts many of his low veld lands into thorn bush. In both cases, the management procedures are obvious but often difficult to implement. Although fire in veld management is still controversial, the bulk of scientific evidence supports the use of controlled fire in late winter after two inches of rain has fallen. This is done on an annual or longer rotation basis depending upon the degree of brush encroachment and other factors. Rejuvenation of thorn scrub country usually necessitates and entails some mechanical manipulation in addition to prescribed fire.

Game and fish management is often combined with parks, outdoor recreation, and tourism. Steyn (1962) has pointed out the advantages of combining these activities in the Transvaal. Hunting seems to be a more appealing sport in the areas of Africa with a close tie in to the English culture. Game birds are seldom shot in many areas, and the typical Afrikaans hunter often excuses his big-game hunting, which he enjoys, as a need to procure his annual supply of biltong, which is tasty and nutritious. Many people active in conservation organizations are little interested in hunting and, because of the past destruction, hunting is often looked at with some question. This same reaction is more evident in the U. S. in the past decade.

GAME, CATTLE, AND HUMAN DISEASE PROBLEMS

Disease is a widespread serious problem in Africa. Many American biologists with East African experience are convinced that if the problem of the tsetse fly and the Nagana disease (trypanosomiasis) of cattle is solved that the big game of East Africa will immediately disappear. This is a very real problem, and man is very efficient at finding ways to eliminate a disease vector; it is hoped that overall ecological considerations will have an opportunity to be heard before the land "under the fly" comes out from under the fly, and it will soon.

Sleeping sickness of cattle (Nagana) and of man have long since been wiped out of South Africa, along with hoof and mouth, rinderpest, anthrax, and malaria. A rather fabulous epidemic of rinderpest swept east and southern Africa around 1897. It resulted in the final wiping out of some endangered grazers. It has also been credited with wiping out the tsetse fly through elimination of the Cape buffalo in some parts of southern Africa as well as some of the smaller antelopes. Actually this most interesting biological phenomena will never be adequately understood since part of it occurred during the savage South African or Boer War in which the British put down the freedom aspirations of the Dutch who had settled and set up the South African Republic (now the Transvaal Province) and the Orange Free State. Since cattle diseases are still a problem in nearby less developed countries, much of South Africa is now fenced off with game-proof fence which is regularly patrolled. There is also a buffer zone of game lands without cattle within these borders.

ENVIRONMENTAL POLLUTION

In general, pollution is a minor matter in all of Africa. However some rivers are covered with heavy foams from detergents, and smog from wood-burning cooking stoves often obscures cities to the point where driving is hazardous. There have been pressures to use heavy aerial distribution of potent pesticides for termite control on the veld. However the general level of science, love of the land, and the conservation ethic will probably result in the solving of these problems before they become really serious.

THE FUTURE

The wildlife resource in South Africa is increasing each year. Big game is making a strong comback. Tourism, game watching, camping, hiking, and outdoor living are highly prized recreational activities. Nature reserves, restocking, protection, hatcheries, and scientific research are increasing. As an example of the quality of game and fish research, almost every parks board and game and fish department publishes its own technical scientific journal and so do several outdoor conservation societies. The author is familiar with six journals devoted to this field published in southern Africa alone. In general, wildlife management has come of age in South Africa and the future looks secure.

BIBLIOGRAPHY

Allen, Durward L.
1954. Our wildlife legacy. Funk and Wagnalls Co., New York. 422 pp.

Cattrick, Alan
1959. Spoor of blood. Standard Press Limited. Howard Timmons, Capetown. 180 pp.

Crockford, J. A., F. A. Hayes, J. H. Jenkins and S. D. Feurt
1958. An automatic projectile type syringe. Vet. Med. 53:115-119.

Harthoorn, A. M.
1962. The capture and relocation of the white (square-lipped) rhinoceros *Ceratotherium simum simum*. The Lammergeyer 2(2):1-9.

Harthoorn, A. M. and J. Bligh
1965. The use of a new oripavine derivative with potent morphine-like activity for the restraint of hoofed wild animals. Res. Vet. Sci. 6(3):290-299.

Player. Ian
1967. Translocation of white rhinoceros in South Africa. Oryx 9(2):137-150.

Riney. Thane and W. K. Kettlitz
1964. Management of large mammals in the Transvaal. Mammalia 18(2):189-248.

Steyn, T. J.
1958. Nature conservation in the Transvaal. Fauna and Flora 9:5-23.

———— 1962. Nature conservation and outdoor recreation. Fauna and Flora 13:4-7.

———— 1966. Personal communication.

Taylor, C. R.
1969. The eland and the oryx. Sci. Amer. 220(1):88-95.

Van Niekerk, J. W. and U. de V. Pienaar
1962. Adaptations of the immobilizing technique to the capture. marking, and translocation of game animals in the Kruger National Park. Koedoe 5:137-142.

Van Zyl. J. H. M.
1962. The meat production of South African game animals I.—The eland. Flora and Fauna 13:35-40.

WILDLIFE QUALITY AND QUANTITY IN SOUTH AFRICA —A REACTION

THANE A. RINEY[1]
Food and Agriculture Organization of the United Nations, Rome, Italy

South Africa is unique and my aim is to suggest something of the variety, complexity, stimulus and challenge in trying to improve the standards of our profession on this vast continent. Here, as in other parts of the world, quality is very subjective to concepts of good or bad raised from personal points of view, and the objectives of wildlife management vary with different forms of planned use, different philosophies, and different social and cultural conditions.

Quantity, or the sum total of wildlife, is a combination of the species. It is easier to be objective about it even though it may be expressed in different ways as indices for comparison, such as in pounds or kilos, or, in some parts of Africa, tons per square mile.

One example restates ideas mentioned by Dr. Jenkins in slightly different terms. It might be useful to consider the setting. The sociological, economic, and ecological factors are the three main settings for the variables affecting consideration to both quality and quantity; and the fun, like problems, comes from making your way delicately or boldly, as your taste dictates, through this inexplicably complicated tangle.

Take a sociological example. If you live along the Senegal River in Senegal, you're of the Mohammedan religion and you do not eat warthogs. This is part of your culture and tradition. The idea of eating a warthog disgusts you. This is a qualitative thing. The warthogs thus thrive and multiply unchecked and become exceedingly abundant—a quantitative effect—and they do such damage to the crops—quantitative activity, not only biological, but strongly economic implications—that they have to be shot using large-scale drives.

So it was in 1961, and every few years, that over a thousand warthogs were shot by the inhabitants of one small village and the carcasses remained where they fell. A French biologist who passed very quickly through this small area—one might be technical and say "stink zone"—one week later, brought the story back to persons of a different religion. All the facts were the same, but they sounded different: "Those so and so's along the river shot over a thousand warthogs the other day for no reason at all except that they were nibbling a few crops and then let them lie. This is a fantastic waste of the most beautiful meat."

If the villagers could get this meat to southern Senegal, it would

[1]Chief, Section of Wildlife, FAO

mean considerable money, far more than the village made in several previous years.

Or if we begin with an economic question, the original factor would start with the question of rare animals and the people who didn't want the animals to disappear. So they captured them and redistributed them. The animals built up, and they finally had to shoot some and they found certain values to shooting the animals and selling the meat. So certain farmers gradually switched from cattle and sheep to wildlife management, simply because it was less expensive per year and they could make more money with wildlife than with cattle.

They personally described their motivation as economic. They want more money in the bank, but one of the reasons they can do this is that game meat is socially acceptable in South Africa, either fresh or dried. This is the quality meat in South Africa. The administrative structure under the leadership of Dr. Steyn is good and technical guidance is good, and proving, last but not least, that there are ecological bonuses for wild and domestic animals in a land which is overgrazed. Even with increased numbers, the ground cover is recovering, a greater primary production is building up, and existence is becoming more stable, more diverse and capable eventually of supporting even more willdlife and, on many farms, a combination of animals, wild and domestic.

No matter where you look, you are submerged in various kinds of quantitative and qualitative considerations rising from this interplay of social, economic, and ecological factors uniquely associated with the problem in hand, the one of research and training. Now, the subject matter is as long as the table of contents of the *Wildlife Review*.

In African national parks the featured wildlife there are sets of political, social, ecologic, economic factors in operation, which results in a very curious interplay of ideas on the quality and quantity of wildlife. The highest quality of tourist experience is when they see the greatest quantity of animals, birds, elephants, moving masses of wildebeests, hundreds of graceful soaring impala, or bouncing springboks; and tourists seem to be absolutely insatiable when it comes to lions, leopards, or cheetah.

The tourist demand leads to certain types of political pressure. This quantity of animals means quantities of tourists, which in turn brings quantities of money. But when our orientation changes, our aim is changed and our interpretations of quality and quantity change. If we can for a moment pretend that we are ecologists whose concern is obtaining maximum density in the habitats and maximum diversity of habitats and, therefore, many types of animals within the parks, then we recognize many of these masses of animals as a part of an irruptive curve; in short, overpopulation downgrading habitat, ever decreasing quality and, of course, the crash in the irruptive sequence with a large loss of animals—the very animals the tourists want so badly.

A book illustrating animals in Kruger National Park simply for identification purposes is used in one of our FAO game management schools in another part of Africa to illustrate poor management, for an unusual number of these animals have their ribs, processes, and vertebrae prominently displayed. To convert tourists into creatures who are pleased to see fewer animals in better physical condition will take education, and this will take time. Anyway, I'm sure you get the point in the difference between qualitative attitudes and the result of political pressures which in turn effect management; and sometimes this operates against the long-term interests of the African national parks.

I have elaborated one example. We can take care of the rest by name dropping. There is a question on introductions. There were over a thousand introductions a year in Africa alone in 1959 and several years before. This raises many issues effecting quality and quantity question.

Game utilization—meat in the tribal areas or for export; hunting; tourism; there's a question of small game. Many questions of quality and quantity are raised here and in the parks of Africa where they are more highly advanced in game management in relation to West Africa, but they are already getting over these questions of quality.

In the formation of appropriate legislation and appropriate policy, it's impossible to come to grips with this elementary question in a developing country without having some kind of quality considerations.

The question of research is worth a separate symposium at some future North American meeting to examine quality and quantity in regard to wildlife research under various situations.

And so go the questions involving animals and species. If we are to improve either qualitative or quantitative aspects of our profession, I feel we must develop, as has been implied by other speakers, a methodology for considering social, ecological factors as well as the economic factors, a combination of these three which will probably lead to most progress in our developing countries.

DISCUSSION

DR. WILKINS: I would like to express appreciation to our participants for their efforts and to you as an audience for your attentiveness.

We have not attempted to define quality; this is still to be adequately defined. We have attempted to open a door to exploration of the question of measuring wildlife values. If you feel these topics should be further explored, I'm sure the sponsoring groups would appreciate your indicating this to them.

TECHNICAL SESSION

Wednesday Morning—March 5

Chairman: ROBERT L. MORGAN
Leader, Statewide Habitat Development, State Game and Fish Department, Bismarck, North Dakota

Discussion Leader: D. O. RETTINGER
Wildlife Research Specialist, Bureau of Sport Fisheries and Wildlife, Albuquerque, New Mexico

WETLANDS AND INLAND WATER RESOURCES

FACTORS AFFECTING WATERFOWL PRODUCTION ON A SPRING-FED SALT MARSH IN UTAH

DONALD E. MCKNIGHT AND JESSOP B. LOW
Cooperative Wildlife Research Unit, Utah State University, Logan

For many years river-fed salt marshes along the eastern shore of the Great Salt Lake, Utah, have been regarded as exceptionally good waterfowl breeding areas. Waterfowl nesting densities and production (defined as the number of young birds reared to flying age per unit area) on these marshes exceed even those of the famous Canadian Prairie Provinces. Results of past studies on Utah's spring-fed salt marshes, which are located principally west of the Great Salt Lake, indicate, however, that waterfowl production on these areas is much lower than on the stream-fed marshes. Approximately 35,000 acres of spring-fed salt marshes in Utah are being managed at present by the Utah Division of Fish and Game and the Bureau of Sport Fisheries and Wildlife. The expense of maintaining these areas is substantial, and it is therefore desirable to secure maximum returns from them in the form of high waterfowl production.

The objectives of this study were to assess waterfowl nesting densities and production on a spring-fed marsh, to investigate various factors affecting this waterfowl population, and to determine which factors were, or had been, limiting waterfowl production on this marsh. This study was initiated in the spring of 1966 and extended through the summers of 1966, 1967, and 1968. The newly-established Fish Springs National Wildlife Refuge, located in the west desert of

Utah, was chosen as the site of the investigation because of its recent developmental history. In 1961, prior to the impoundment of spring waters on the area, this refuge's waterfowl production was estimated to be 250 to 350 ducks, mostly mallards (*Anas platyrhynchos*). By 1968 calculated waterfowl production had risen to 3,600 ducks, including nearly 1,000 redheads (*Aythya americana*). It was believed that by determining what conditions caused this remarkable increase in waterfowl use following marsh development it would be possible to ascertain which factors were responsible for low duck production on other spring-fed areas.

DESCRIPTION OF THE STUDY AREA

The Fish Springs Refuge, located in an area which receives an average annual precipitation of about 7 inches, is almost entirely dependent upon the outflow of its springs for water during the summer months. These springs provide about 45 to 50 second-feet of constantly warm (about 80°F.) and highly saline (2173 p.p.m. of dissolved solids) water throughout the year. Vegetational succession on this area follows a course primarily dictated by soil salinity (Bolen, 1964), and marsh vegetation is limited mainly to halophytic species.

From 1962 to 1964 portions of the Fish Springs marsh were drained to facilitate the construction of dikes and roads. Now the entire area is partitioned into nine large impoundments (units), each consisting of a permanent earthen dike and its impounded waters. Before this work commenced Olney's bulrush (*Scirpus olneyi*), which represented terminal-emergent marsh vegetation according to Bolen (1964), was the predominant plant on this area. When much of the original marsh was drained, however, this species died in many places. Emergent vegetation is now sparse in most of these newly-formed impoundments and consists primarily of remnant stands of the once abundant Olney's bulrush, small communities of cattail (*Typha angustifolia*) and hardstem bulrush (*Scirpus acutus*), and widespread stands of alkali bulrush (*Scirpus paludosus*). At present, wire rush (*Juncus balticus*) is the most abundant marsh plant at Fish Springs, where it forms broad meadows in low-lying and wet areas and borders along slough shorelines. Extensive meadows of saltgrass (*Distichlis stricta*) carpet plains adjacent to these impoundments, and the mineral-rich waters of this area produce an abundance of submergent vegetation, primarily widgeongrass (*Ruppia maritima*) and muskgrass (*Chara* spp.).

WATERFOWL PRODUCTION ON THE STUDY AREA

Waterfowl breeding pair censuses, nesting and banding studies, and brood inventories were conducted during the summers of 1967 and

1968. Populations of breeding waterfowl averaged approximately 900 pairs, or 128 pairs per square mile of marsh habitat during this period. Mallards, cinnamon teal (*Anas cyanoptera*) and redheads comprised about 80 percent of these birds. Gadwalls (*Anas strepera*), which are the most important nesting species on stream-fed marshes of Utah (Williams and Marshall, 1938), averaged only 5 percent of this breeding duck population.

The duck nesting season at Fish Springs extends from late March, when mallards begin to lay, until August when the last gadwall, redhead and ruddy duck (*Oxyura jamaicensis*) nests hatch. In 1967, nesting densities on sample plots encompassing 108 acres of representative marsh habitat were 0.89 nests per acre. Nesting densities on these plots in 1968 were 1.21 nests per acre. Apparently heavy rainfall in late May and early June 1967, which flooded much nesting habitat, was responsible for lower nesting densities that year. These nesting densities are only slightly lower than those found on the Bear River Migratory Bird Refuge, one of Utah's stream-fed marshes (Williams and Marshall, 1938).

In 1967 and 1968 a total of 312 duck nests representing 10 species were studied and their fates determined. Overall nest success was 63 percent. Predators, principally coyotes (*Canis latrans*) and striped skunks (*Mephitis mephitis*), destroyed 25 percent of all nests. Calculated duckling mortality rates during 1967 and 1968, respectively, at Fish Springs were 19 percent and 16 percent.

During the two years of this nesting study, 76 percent of the 84 redhead and ruddy duck nests located were situated on dry land sites. These ducks, which usually nest in clumps of emergent vegetation over water (Kortright, 1953 and many others), had apparently circumvented shortages of preferred nesting cover because other aspects of this marsh were favorable.

Duck production on the study area averaged about 3,000 ducks or about 430 ducks per square mile of marsh habitat a year in 1967 and 1968. This production figure is somewhat misleading, however, as much of the marsh consisted of flooded salt flats providing minimal amounts of nesting cover and receiving little use by duck broods. If total duck production were based on that portion of the refuge containing suitable waterfowl habitat, resultant production figures would approach the one to three ducklings per acre cited by Jensen and Chattin (1964) for Utah stream-fed marshes.

FACTORS AFFECTING WATERFOWL PRODUCTION

Waterfowl production on any marsh is dependent upon a tremendous multiplicity of interacting ecological factors. Although it was beyond the scope of this study to gather exhaustive qualitative and quantitative data pertaining to all of these factors, such information was obtained when it appeared that the impact of a specific condition might have been a limitation to waterfowl production. Ultimately many characteristics of ducks themselves and the environment at Fish Springs were virtually eliminated as being responsible for low duck production at the Fish Springs marsh prior to its development. Then, with the majority of these factors deemed not critical at this marsh, further research was directed towards ascertaining which factors were truly important considerations.

When this investigation was initiated in 1966, much of the habitat available for waterfowl at Fish Springs consisted of newly-inundated portions of the original marsh which contained little submergent and emergent vegetation. Sloughs and channels, originally choked with widgeongrass and bordered with Olney's bulrush and other emergents (Bolen, 1964), were nearly devoid of aquatic vegetation. All that remained in these impoundments was the dead and partially decomposed remnants of emergent vegetation and bassia (*Bassia hyssopifolia*), which had invaded these areas following drainage. Two of the nine impoundments, however, had only been dewatered for one year (1962) and by 1966 provided marsh habitat that appeared to have the constituents necessary to attract breeding ducks. Waters of these units contained lush growths of submergent vegetation, and shorelines and sloughs maintained extensive stands of Olney's bulrush, cattail, and other emergents.

Research efforts in 1966 consisted primarily of obtaining brood census data. Unexpectedly, these data and field observations indicated that, in terms of duck broods per acre of marsh, the newly-flooded areas which had been part of the original marsh were being most heavily used by waterfowl. This differential brood use between the older and seemingly more favorable portions of the marsh and the recently-impounded areas provided a possible explanation for the great increase in waterfowl production at Fish Springs. The reason for the apparent preference by duck broods for newly-impounded areas was not explainable in terms of vegetative cover or plant food since these areas contained less of these elements than did the older, more stabilized portion of the refuge. However, qualitative sampling of aquatic invertebrates, initiated that summer, indicated that waters of the newly-inundated portions of the original marsh produced much higher populations of low trophic-level aquatic insects (families Chironomidae and Corixidae) than were produced in the older units.

It is now understood that invertebrates, particularly aquatic insects, comprise an important source of high-protein food for newly hatched ducklings and laying ducks (Chura, 1961 and Leitch, 1964). Therefore, it appeared that observations of high populations of aquatic insects in the waters of newly-impounded areas provided an insight into the reason for high brood use of these areas. Consequently a plan for quantitatively sampling these insect populations was established on the study area

According to Lattin (1963), all existing techniques for sampling aquatic insect populations are inadequate or impractical for purposes of statistical analysis. In spite of obvious shortcomings, however, it is felt that the methods utilized provided indices of the abundance of more numerous organisms which were acceptable for comparative purposes. Because Chura (1961) found that the benthic insect family Chironomidae comprised the bulk of animal food ingested by mallard ducklings at the Bear River Migratory Bird Refuge in Utah, bottom samples were taken at each collection site. The family Corixidae and other free-swimming aquatic insects were also important in the diet of these ducklings, so samples of these invertebrates were similarly collected.

Aquatic insect sampling in the summers of 1967 and 1968 indicated that: 1. populations of aquatic insects were extremely high in newly-impounded waters containing little submergent vegetation; 2. after several years of continuous impoundment these waters contained tremendous quantities of submergent vegetation but produced relatively little animal food for ducklings; 3. populations of aquatic insects in the original marsh were probably low except in areas recently disturbed by muskrats, man, or other such agencies; and 4. summertime dewatering of one entire impoundment and portions of another resulted in a tremendous increase in aquatic insect populations on these areas the following year. Differences in insect populations between recently-disturbed and stabilized portions of the original marsh were great (Table 1), and it is apparent that the quantity of animal foods available for ducklings on the stabilized areas was much less than on the newly-flooded portions of the marsh. Apparently the decaying vegetation and soft, loamy bottoms of areas drained and subsequently inundated provided optimal conditions for low trophic-level insects.

TABLE 1. A COMPARISON OF STANDING CROP POPULATIONS OF LOW TROPHIC-LEVEL AQUATIC INSECTS AT SEVERAL SAMPLING SITES IN JULY 1968.

Sampling Site	Average no. of Corixidae in one cubic meter of water	Average no. of Chironomidae larvae in 0.01 square meter of bottom
Impoundment which was drained completely, summer 1967	494.0	69.6
Impoundment which was dry only during August and September, 1967	799.0	108.0
Impoundment continuously flooded for three years	3.0	6.0
Impoundment continuously flooded for six years	4.5	9.0
Undisturbed original marsh	21.5	5.9

Research on waterfowl populations concurrent with this invertebrate sampling indicated that brood use was highest on the newly-flooded impoundments and tapered off after three years of continuous inundation. Pools which were allowed to go dry during the late summer months were most heavily utilized by broods the following year. Those impoundments with stable year-around water levels developed dense stands of submergent vegetation, were used extensively for nesting and by migrant ducks but were least used as brood-rearing areas.

DISCUSSION

Although water manipulations, particularly drawdowns, have been recognized for some time as an important tool for marsh management (MacNamara, 1957 and Kadlec, 1962), the beneficial effect of drawdowns on populations of aquatic invertebrates has apparently not been previously noted. Leitch (1964) pointed out how the fertility of prairie ponds was increased when drought exposed and aerated pond bottoms, thus promoting decomposition of organic matter. This worker similarly indicated the importance of a high-protein diet to laying female ducks and young ducklings. Perhaps then, increased populations of low trophic-level aquatic insects produced when these ponds are reflooded during years of adequate precipitation account more for "booms" in waterfowl populations than do resultant increases in food plants.

For many years biologists have attempted to categorize and evaluate factors influencing the productiveness of marshes for waterfowl. The tremendous complexity of marsh ecosystems and the great diversity of marsh types on this continent have made this a nearly impossible task. Recently, however, ecologists have utilized sophisticated concepts of energy flow to analyse biological systems. Much of this work is still purely speculative, but the cognizance of some aspects of energy flow within aquatic systems may prove useful in marsh management and explain what happened at Fish Springs after marsh development.

According to Lindeman (1942), highly productive (eutrophic) closed systems of water, like the spring-fed marshes and the prairie potholes, become senescent (distrophic) as a result of long-continued sedimentation, and their productivity greatly declines. This decreased productivity is probably reflected by lowered amounts of aquatic insects and, at Fish Springs for example, probably resulted in low waterfowl production. Drainage of this senescent marsh and the resultant increased rate of decomposition of organic matter probably resulted in a return to the highly productive eutrophic stage-equilibrium phase of succession described by Lindeman (1942).

SUMMARY AND CONCLUSIONS

A tremendous increase in waterfowl utilization and production at the Fish Springs marsh occurred following the impoundment of its spring waters. The creation of large and permanent bodies of water undoubtedly made this area more attractive to redheads, gadwalls, and other duck species which prefer large and open expanses of water for brood rearing (Keith, 1961). However, the presence of large bodies of water did not alone explain this increased waterfowl production, as evidenced by the low brood use of flooded salt flats at Fish Springs and the low waterfowl production on impounded waters at other spring-fed marshes in Utah.

Aquatic invertebrate sampling in waters inundating portions of the original marsh indicated that these waters produced tremendous quantities of proteinaceous foods for ducklings immediately following their impoundment. These newly-flooded portions of the Fish Springs marsh, rich in animal food, were apparently the key to the increase in waterfowl production on this area. This increase in production appeared to be similar to the "reservoir effect" familiar to fisheries biologists, and the use of impoundments with stable water levels for brood rearing tapered off after several years. Units which were allowed to dry out during the late summer months, on the other hand, were heavily utilized by duck broods the following year. Nesting cover, as evidenced by the unusual nesting habits of redheads and ruddy ducks at Fish Springs, was apparently not an important limitation on this marsh and may not be as critical in other areas as is believed by some biologists.

These studies indicate that if impoundments on the spring-fed salt marshes are periodically drained and allowed to remain dry for several months in the late summer, waterfowl brood use of these areas will be substantially increased in following years. Done on a rotational basis, with newly-flooded units serving as brood rearing areas and older impoundments furnishing nesting cover and high levels of plant foods for adult ducks, these marshes should remain productive indefinitely.

In addition to providing management recommendations for Utah's spring-fed salt marshes, results of this study also have more diverse implications. Certainly the importance of readily available animal foods in adequate quantities for young ducklings must be considered in the management of waterfowl breeding areas. If aquatic invertebrate populations on other waterfowl marshes are found to be a limitation to waterfowl production, as they appear to be at Fish Springs, management based on concepts of energy flow within a marsh ecosystem will provide us with a useful new tool. The characteristic growth pattern of animal populations in a sigmoid curve has led us to attempt to manage game animals at levels where population growth rates are highest in order to gain the greatest harvest. Should we not attempt to manage our waterfowl marshes at a stage of succession which will yield the greatest waterfowl production?

ACKNOWLEDGMENTS

This investigation was supported by a Public Health Service fellowship (5-F1-GM-32, 266-03) from the National Institute of General Medical Sciences. Gratitude is also expressed to the Branch of Refuges, Region II, Bureau of Sport Fisheries and Wildlife for providing living facilities at the Fish Springs National Wildlife Refuge. The authors are particularly indebted to Mr. Robert Yoder, refuge manager, whose assistance and interest were instrumental in the successful completion of the field work.

LITERATURE CITED

Bolen, E. G.
1964. Plant ecology of spring fed salt-marshes in western Utah. Ecol. Monog., 34(2): 143-166.

Chura, N. J.
1961. Food availability and preferences of juvenile mallards. Trans. N. Amer. Wildl. Conf., 26: 121-134.

Jensen, G. H., and J. E. Chattin
1964 Western production areas. In: Waterfowl Tomorrow. (eds. J. P. Linduska and A. L. Nelson) U. S. Govt. Printing Office, Wash., D. C.

Kadlec, J. A.
1962. The effects of a drawdown on a waterfowl impoundment. Ecology 43(2): 267-281.

Keith, L. B.
1961. A study of waterfowl ecology on small impoundments in southeastern Alberta. Wildl. Monog. No. 6.

Kortright, F. H.
1953. The ducks, geese, and swans of North America. The Stackpole Co., Harrisburg, Pa., and Wildl. Mgmt. Inst. Wash., D. C.

Lattin, J. D.
1963. Equipment and technique. In: Aquatic Insects of California. (ed. R. L. Usinger) Univ. of Cal. Press. Berkeley and Los Angeles.

Leitch, W. G.
1964. Water. In: Waterfowl tomorrow. (eds. J. P. Linduska and A. L. Nelson) U. S Govt Printing Office, Wash, D. C.

Lindeman, R. L.
1942. The trophic-dynamic aspect of ecology. Ecology 23: 399-418.

MacNamara, L. G.
1957. Potentials of small waterfowl areas. Trans. N. Amer. Wildl. Conf., 22: 92-96.

Williams, C. S., and W. H. Marshall
1938. Duck nesting studies, Bear River Migratory Bird Refuge, Utah, 1937. J. Wildl. Mgmt., 2(2): 29-48.

WHAT IS HAPPENING TO THE WETLANDS?

PHILIP B. AUS
Bureau of Sport Fisheries and Wildlife, Devils Lake, North Dakota

The wetlands of North America come closer than any other single natural resource to fulfilling the needs of today's people suggested by the theme of this conference, "Conservation in an Urbanizing Society."

The stream and the marsh add more to the diversity of the natural environment than any other landscape features. Wetlands are production, migration, or wintering habitat for the fish and wildlife species most important to people.

Wetlands support a greater variety of plant and animal life than any other habitat segment. The elimination of a wetland can mean the loss of a flood storage basin, an area of natural beauty, a groundwater recharge area, or a fish and wildlife habitat. These are direct aesthetic and economic losses to man.

Wetlands are ideal natural laboratories where ecological relationships can be demonstrated to, and studied by, an urban population. A wetland fills the need of the city dweller in his search for space that is green and alive. The marsh and stream can provide the quiet areas where a member of an urbanizing society can find and renew himself through association with natural resources.

Wetlands, with a multitude of values, are an important resource from the Pacific to the Atlantic, from the Arctic to the Gulf Coast. Yet, tremendous losses are taking place today in all types of wetland habitat. Coastal, prairie, and bottomland wetlands are being destroyed by rural and urban activities throughout North America. Their historic classification as "wasteland" has contributed to public attitudes regarding wetland values. Wetlands are drained for airport and highway construction, agricultural reclamation and municipal expansion. They are selected as sites for dumps and landfills. Mosquito control, intensive recreation, pollution and dam construction eliminate or reduce their quality.

Though not always spectacular in terms of acreage, each wetland lost comes from an ever-declining base. This continent's wetland base and variety decline, while methods of destruction increase in scope, intensity, and sophistication. Short-term economics has assigned a greater dollar value to a drained or filled marsh than to one in a natural condition.

Approximately 52 million of the 127 million acres of wetlands present in the United States at the time of settlement have been drained (Harmon, 1968). Much of the remaining acreage is threatened. Many wetlands also have been reduced in wildlife value and quality. Ten million wetland acres have been drained in Minnesota in the state's history (Shoop, 1968). Connecticut has only 20 square miles of good wetland area left (Boyle, 1967). Iowa, once an important waterfowl and wetland state, had its tall-grass prairie-pothole association reduced from six million acres to 50,000 acres as early as 1938 (Bennett, 1938). One hundred thirty-one million acres of land in 39 states have been drained for agricultural purposes (Census of Agriculture, 1959).

Streeter (1968) made clear the threat that reclamation poses to wetlands in the United States. He stated, "They are a new breed of land developers making millions of acres of good new farm land out of country almost worthless, some by draining . . . ." North Carolina has two million acres of inland swamp suitable for conversion to cropland, according to Streeter (1968). He described in detail an 18,000-acre project in Hyde County which involved drainage of lands under two feet of water. He further described the clearing and drainage of low-lying hardwood bottomlands in Arkansas, Mississippi, and Louisiana. To these land developers, drained wetland acres are dollars. Most land reclamation in the eastern United States involves wetland drainage and channelization. The Senate Select Committee on National Water Resources (1959) estimated that drainage could convert 34,800,000 acres in the eastern United States to lands suitable for cultivation.

In the pothole country, cropland acres also are in great demand. Unbroken prairie lands are now rare; thus, agricultural land developers seek another type of "new land." Prairie marshes are often productive of agricultural crops when drained and therefore receive first priority in the search for "new land."

Wetland drainage, after nearly eliminating the marsh resources of Illinois, Indiana, Iowa, and southern Minnesota, expanded north and west across prairies of the Dakotas, Manitoba, Saskatchewan and Alberta. This destruction is spreading at a rapid rate despite recent major conservation efforts to preserve and emphasize the positive values of wetlands. Reduction of federal drainage assistance and aggressive state and federal land acquisition programs have not stopped wetland drainage.

Wetland losses continue to increase in the pothole area of the Dakotas and Minnesota. Between 1959 and 1966 an average of 138,000 wetland acres were drained each year in the three major pothole states (President's Council on Recreation and Natural Beauty, 1968). Approximately 80,000 acres of the Type III, IV and V (permanent and semi-permanent) marshes in the 60 most important waterfowl producing counties of Minnesota and North Dakota were privately drained in the period 1966-1968. In twelve northeastern North Dakota counties, private drainage eliminated 21 percent of the Type III, IV and V wetlands during these three years. Much of this drainage was completed into outlets constructed in the past with public funds or constructed in anticipation of new publicly financed drainage outlets.

Laws enacted have been instrumental in reducing wetland drainage with public funds but are not the entire answer. The passage of Public Law 87-732 in 1962 restricting the use of U. S. Department of Agriculture funds for drainage of wetlands of high value to wildlife on individual farms in the three prairie pothole states slowed but did not stop drainage. The same was true of the proviso in recent Agricultural Appropriations Acts which prohibits the use of Agricultural Conservation Program funds to drain Type III, IV and V wetlands. That proviso has been included in the Agricultural Appropriations Act each year since 1962, at the insistence of Congressman Reuss of Wisconsin.

Agricultural landowners drain wetlands for a number of reasons. Two primary reasons are to secure additional cropland and to accommodate larger farm machinery. Today's economics have forced many farmers to become almost intolerant of any acre not producing immediate and direct cash income. Some landowners regard wetlands as an obstacle in their desire for an orderly landscape. There has been an extensive conversion of farm operations from traditional livestock-small grain farms to single-purpose grain operations in the eastern Dakotas and the Canadian prairie provinces. This results in increased wetland drainage. Drainage will eliminate more prairie wetlands as agricultural markets expand, as farm units increase in size, as farm machinery becomes larger and more sophisticated, and as the trend toward clean and intensive farming continues.

Highway construction projects modify and destroy wetlands. Improved coordination among governmental agencies helps reduce the impact of road construction, but in nearly all cases there is a direct loss. Local highway officials often oppose standards which are based on national resource needs. Frequently, road construction improves or provides outlets for indirect wetland drainage.

Federal water projects constructed by the Bureau of Reclamation, Corps of Engineers, and other agencies, as well as those constructed with the assistance of federal agencies such as the Soil Conservation Service, have historically been a major factor in wetland destruction. Today these projects still threaten a variety of wetland habitats. It is not difficult to plan a potentially destructive project in a manner which will consider and protect all resources. A must in any water project plan is a basic understanding and recognition of the values of wetlands, to both wildlife and human environments. It is imperative that preservation and wildlife agencies participate in the initial planning stages of any Federal water project.

The Watershed Protection and Flood Prevention Act of 1954 (P.L. 566) was considered to be the ultimate conservation approach to the planning of resource development. The application of P.L. 566 in certain parts of the United States has presented problems to fish and wildlife (Madsen, Kozicky, 1966; and Jahn, 1966; Poole, 1968). Local sponsors of P.L. 566 projects in the pothole country want drainage with public funds, and federal and state agencies must resist strong pressures and must uphold their resource responsibilities. These small watershed projects, administered by the Soil Conservation Service, can affect wetlands in the Dakota and Minnesota prairies in one of two ways. They can either extend the direct and indirect destruction of wetlands which occurred in early P.L. 566 pilot watershed projects in Minnesota (Southwick, 1966) or they can accomplish total resource planning, including wetland preservation.

The destructive potential of Flood Prevention and Watershed Protection Projects in the pothole country is great. The Starkweather Watershed project (P.L. 566) proposed in northeastern North Dakota threatens 40,000 acres of prime waterfowl production marshes, as well as some of the most important goose migration lakes in the Central Flyway. Forty-eight P.L. 566 projects in North Dakota are in the planning or construction stage.

Locally sponsored flood control and drainage projects take a nationwide toll of wetlands. In North Dakota, local water management districts have broad authority over projects affecting wetland resources. Local sponsors can receive state financial and technical assistance and federal technical assistance if they agree to construct multi-purpose projects with strong wetland preservation features. All too often, sponsors choose the single-purpose drainage project and assume all project costs. In 1966, a North Dakota county drain protect began drainage of Rush Lake, a 6,000-acre marsh which produced an estimated 15,000 ducks annually, and provided an outlet for private drainage in a watershed containing some 30,000 acres of waterfowl production wetlands. There is yet little consideration of wetlands as a valuable resource by county-level water planning groups. Outmoded water laws which permit such projects offset federal policies and programs designed to protect resources of national importance.

The same land-use operations that have crippled the wetland resource in the United States are beginning to take the same destructive toll of marshes all across the Canadian waterfowl production prairies. Drainage, filling, and clearing are accelerating in Alberta, Saskatchewan and Manitoba. Quantitative data are lacking, but from 1965 to 1968 I saw wetland drainage increase in intensity and sophistication each year. Expanding exports of grain have created a demand for more cropland acres, and the clearing of aspen woodlands, the filling and drainage of wetlands are increasingly common features of the prairie landscape. The Honorable W. Ross Thatcher, Premier of Saskatchewan, in an address at the annual convention of the North Dakota Association of Soil Conservation Districts on October 28, 1968, said that 300,000 acres of land had been cleared for farming during that year. Drainage in the Minnedosa area of Manitoba, one of North America's more important canvasback-producing areas, is especially severe.

There is progress in preserving wetlands from drainage, filling, pollution and other destructive practices. Several states have passed laws to curtail wetland destruction. State agencies, through acquisition programs, have preserved a variety of wetland areas. Private organizations and foundations make important contributions to wetland preservation and development. A number of federally administered programs have the potential to protect and acquire wetlands for recreation, areas of natural beauty, wildlife production and protection, wilderness areas and natural environmental features.

In 1958 Congress passed P.L. 85-585 which authorized the Bureau of Sport Fisheries and Wildlife to acquire wetlands in the prairie pothole region through the Waterfowl Production Area Program. In this program, vital production marshes are preserved both by outright purchase and by perpetual easements prohibiting drainage, filling, and burning of wetlands. The Canadian Wildlife Service initiated a preservation program in 1967 aimed at protecting two-thirds of 6,000,000 acres of major duck-producing marshes (Munro, 1967). These programs were brought about through a concentrated effort by concerned individuals and groups across all four flyways and the international border. The progress made in the Waterfowl Production Area Program is important to all interested in waterfowl and wetlands. To date, over 206,000 acres of marsh and upland have been purchased and 668,000 wetland acres protected by easement. Unfortunately, many supporting interests believed the problems facing wetland preservation were solved by this legislation. There was a settling back by concerned individuals to wait for the program to do the job alone. But there was no suspension of drainage activity.

Of the many methods to preserve wetlands that have been considered, two other possibilities remain that can save what is needed in the short time this resource can be protected against private exploitation. A nationwide public resource program together with legislative restrictions on wetland destruction can maintain the wetland resource.

A land retirement program with consideration for wetlands is proposed in the water bank program. Such programs must be long-term and financially competitive in order to assure landowner participation and to secure protection of wetlands in high land-value areas. Land retirement is advocated by the Commission on Food and Fiber (1967).

State laws can protect wetlands. New York, Massachusetts, Rhode Island, and Maine have passed laws to minimize wetland loss. Legal restrictions on wetland drainage would benefit flood control, natural beauty, groundwater recharge, outdoor recreation, water pollution, and fish and wildlife resources. Zoning has been effective in controlling land use in some urban areas. The principles of zoning seem to have real potential to protect wetlands on private lands.

The President's Council on Recreation and National Beauty (1968) stated what has to be done:

> Ultimately, the Nation will have to determine how much wetland must be preserved, identify the areas which can best satisfy the needs, and provide for their permanent protection. In the meantime, the States can end needless destruction of wetlands and make sure that any conversion of wetland areas is carefully regulated. The Council recognizes the public interest in estuaries and inland wetlands because of their outstanding scenic, fish and wildlife habitat, economic, recreation, and other values, and recommends that the States which have not already done so establish systematic review procedures for thorough consideration by natural resource and recreation agencies of the values of wetland and estuarine resources before private or public development projects are allowed to encroach upon them.

To close this discussion on a positive and promising note, I would like to review the wetland protection accomplishments secured in North Dakota in a local project initially called the Fairdale Drain. This is a first in really comprehensive project planning and resource protection, and I hope it sets an example in total resource planning for all water projects.

In the Fairdale project, the Walsh County Water Management Board proposed a legal drain project in 1963 to alleviate downstream flooding and provide outlets for additional upstream drainage. In North Dakota, a certain planning criteria exists on water projects when local people apply for state or federal funds. A committee, representing the State Game and Fish Department, Soil Conservation

Service, State Water Commission, and Bureau of Sport Fisheries and Wildlife, sets project wildlife habitat conservation standards to be met in order to qualify for public funds. In the Fairdale project, the recommendations were: (1) compensation for all wildlife habitat directly destroyed by channelization; (2) preservation of all Type IV and V wetlands; and (3) preservation of 75 percent of the Type III wetland acreage in the entire watershed. The Fairdale group accepted the recommendations but had difficulty meeting the estimated local construction costs. Application was then made to have the Fairdale Drain submitted as a supplement to the Middle South Branch Forest River Small Watershed Project in order to receive more federal technical and financial assistance. This action was approved, and the Soil Conservation Service asked that the legal drain wildlife requirements for wetlands preservation be a part of this P.L. 566 project.

A work party consisting of the local water board, Soil Conservation Service and Bureau of Sport Fisheries and Wildlife contacted each landowner in the watershed to secure the necessary preservation. Landowners could sign a Bureau of Sport Fisheries and Wildlife perpetual easement for which payment would be made or grant a 50-year no draining, burning or filling easement to the Walsh County Water Management District. Agreements to preserve 2,369 acres of Type III, IV and V marshes or 73.1 percent of the wetland acres within the watershed have been secured in the Fairdale project.

An accomplishment of this magnitude is a real milestone in federally assisted water projects. Similar approaches are being tried in other North Dakota watersheds. However, success is directly related to local interest in drainage and varies in each project. Wetland preservation guidelines, such as those applied successfully in the Fairdale project, or satisfactory alternatives, need to be incorporated into the Watershed Protection and Flood Prevention Act. The basic methods used in Walsh County, North Dakota, to preserve important waterfowl production habitat could be applied in a variety of public projects anywhere in the United States. Such action would limit the use of public funds where local sponsors are interested primarily in drainage and where a satisfactory working relationship among concerned interests is lacking.

Wetlands today are faced with perhaps the greatest threat since settlement of this continent. Each wetland drained, filled, or polluted comes from a greatly reduced natural resource base. Individual wetland types and the total natural wetland resource are rapidly approaching a stage where they can be placed in a remnant or rare category. Preservation of every acre is important. If we will act now, we can retain the many values, the variety and productivity of North American wetlands.

LITERATURE CITED

Bennett, Logan J.
1938. The blue-winged teal, its ecology and management. Collegiate Press, Inc., Ames, Iowa

Boyle, Robert H.
1967. How to stop the pillage of America. Sports Illustrated, Vol. 27, No. 24, Dec. 11, 1967 pp. 40-53

Harmon, Keith
1968. Midwest and nation's wetlands disappearing. Agricultural Information Department, N.D.S.U. College of Agriculture. 2pp

Jahn, L. R.
1966. A wildlife organizations views on P.L.566 Wildlife Management Institute, Washington, D.C. Presented at the U.S. Soil Conservation Midwest Biology Workshop, Madison, Wisconsin, July 25-29, 1966. 16 pp

Madson, J. and Kozicky, E.
1966. A hidden thorn. Olin-Mathieson Chemical Corporation, Conservation Volunteer, Minnesota Dept. of Conservation, March-April; 39-40

Munro, David A.
1967. The prairies and the ducks. Reprint from the Canadian Geographical Journal, July, 1967. 12 p.

National Advisory Commission on Food and Fiber
1967. Food and fiber for the future. U.S. Government Printing Office. 361 p.

Poole, Daniel A.
1968. Weaknesses in the public law 566 watershed program. Fifteenth National Watershed Congress, New Orleans, Louisiana, May 26-29, 1968. pp 42-51.

Senate Select Committee on National Water Resources
1959. Committee print 12. U.S. Government Printing Office

Shoop, Jim
1969. $650,000 "sick" lakes cure sought. Minneapolis Star, Vol. XCI, No. 55, Jan. 28, 1969, pp la, 2a

Streeter, C. P.
1968. New ladn—right under our noses. Farm Journal Vol. 92, No. 9, Sept. 1968, 30 p.

The President's Council on Recreation and Natural Beauty
1968. From sea to shining sea, U.S. Government Printing Office. 304 p.

U.S. Department of Agriculture
1959. Census of agriculture, drainage of agricultural lands, Vol. IV

DISCUSSION

MR. RETTINGER: Thank you for that fine presentation on a very important subject.

MR. HAROLD DUEBERT (North Dakota): In the glacial praisie region there are three major glacial land forms. In which one of these zones is drainage most serious and, further, could you give some idea of the breeding population on this habitat and its production potential?

MR. AUS: Drainage in the Red River Valley has been extensive for a number of years, and wetlands have been trimmed to an absolute remnant there. The most serious drainage in North Dakota and in most of the pothole states occurred on lands that are intensively farmed and which are increasing in value each year. I estimate that breeding populations would run 30 pairs per square mile over eastern North Dakota. However, the drainage problem is most severe in this region.

MR. GARY DROWN (Nebraska): Would you give a generalized evaluation of the present condition of our wintering waterfowl habitats? Do you evaluate them as adequate, abundant, or limited?

MR. AUS: The habitat problems are severe in wintering habitat. My area of work is the prairies, but I recognize the losses and the threats to habitat throughout the United States. I am concerned with all of it. Perhaps someone from that region could give us a more specific answer.

MR. JOHN M. ANDERSON (Connecticut): One of the main reasons why private wetlands owners drain their property is because they can make more money on it through some other form of land use. I submit that part of this is our own fault. We take the attitude that if he will not turn the marsh into a public shooting ground, if he maintains a private club or leases it to a group of hunters then he is being selfish. The state and federal wildlife agencies say that if this is what he is going to do, then he can protect his own property. In many states throughout the Midwest he cannot call the game warden to protect his property against trespassers. He has to call the Sheriff, and this may be one way for us to get even with him for maintaining his cash income. However, it certainly is not increasing his incentive to keep his wetlands wet.

MR. JAMES HOLT (Maryland): We have just completed a wetlands study in which we found we have lost 23,000 acres since 1942. Maryland only had 300,000 acres to start with. Our biggest problem to date has been agricultural drainage, which has amounted to 50 percent of our wetlands loses. Right now Maryland is facing a real threat to its coastal wetlands from land development, and this, of course, is the open space you talked about in your paper. Land developers have seen these open spaces, although they don't want to hook into them in their present condition.

MR. RETTINGER: It has become apparent throughout this Conference that we must attack the saving of these wetlands with renewed vigor. We no longer can withstand the loss of the wetlands, if we are going to sustain much of our wildlife population. There has been a complacent attitude among many groups. I think it is time we acted and did so vigorously, especially if we want to continue some of these precious wildlife species that we have been talking about, as well as multiple use of the wetlands. This is a vital area of concern to all people who are concerned with wildlife today.

NORTH DAKOTA'S WATER BANK PROPOSAL

KEITH W. HARMON
North Dakota State University, Fargo

WETLAND GAINS AND LOSSES

Numerous state and federal programs have been initiated to preserve wetlands in the prairie pothole region of the United States. P.L. 85-585 (1958) authorized the Secretary of Interior to preserve small wetlands by easement or purchase for waterfowl production P.L. 87-383 (1961) authorized a 105 million-dollar, interest-free loan to accelerate the federal small wetlands program. Minnesota, North Dakota, and South Dakota also have programs designed to preserve wetlands. State programs have made some gains in saving wetlands, but are often underfinanced and at times nonoperational due to lack of funds.

Restrictions also have been placed on use of federal funds for cost-shared drainage. P.L. 87-732 amended the Soil Conservation and Domestic Allotment Act to require the Secretary of Interior to determine if wildlife preservation would be harmed by drainage of certain wetlands in Minnesota, North Dakota, and South Dakota. The Reuss Amendment to the Agricultural and Related Agencies Appropriation Bill prohibits technical or financial assistance for drainge of Type III, IV, and V wetlands nationwide. Little, if any, state legislation exists in the prairie states for reduction of drainage. In fact, state laws are oriented toward drainage.

Despite state and federal wetland acquisition programs and federal legislation to restrict cost-shared drainage, private drainage of wetlands continues to increase. Private drainage surveys were conducted in Minnesota, North Dakota, and South Dakota by the Bureau of Sport Fisheries and Wildlife in 1966, 1967, and 1968. During these three years, approximately 101,300 acres of Type III, IV, and V wetlands were drained. In 1968, 21 percent of the Type III, IV and V wetlands were drained in two northeastern North Dakota counties.

Provided Bureau of Sport Fisheries and Wildlife wetland preservation goals are reached in Minnesota, North Dakota and South Dakota, about one million acres of wetlands will remain controlled by private landowners and need legal and/or financial incentives to protect them from drainage. Should these acres in the United States be lost and similar large-scale losses occur in the Canadian prairies, large duck populations and the sport of duck hunting may become a memory to many attending this conference.

Wetland preservation programs, as well as most of the conservation movement, are strongly affected by economics. A basic assumption of economics is that landowners tend to use their land resources for those purposes which promise the highest economic return (Barlowe, 1958). Regardless of public land managers' opinions of this premise, it is a fact that must be considered.

When considering wetland preservation, it is essential to remember that the resource is largely in private ownership. Unless the landowner's management objective of maximizing income is fulfilled, no preservation program can be completely successful.

The economics of farming are such that drainage of wetlands in North Dakota, as in other states, is an attractive *economic* alternative for most landowners. In addition, there has never been a widespread land ethic among landowners to preserve wetlands. Time is short and there is not enough time to develop one. As tragic as this may seem, this too is a fact.

FARMING TRENDS IN NORTH DAKOTA

A brief summary of North Dakota's farm economy seems essential. Farm production and income are the major contributors to North Dakota's economy. A major portion of the populaton, both rural and urban, is dependent either directly or indirectly on agriculture. North Dakota ranks first in the nation in production of barley, rye, and flax. Its farmers produce 90 percent of the nation's durum and 60 percent of the hard spring wheat.

North Dakota farmers export about 85 percent of their agricultural output either to domestic or foreign markets. Thirty to 40 percent of the hard spring wheat and durum produced in North Dakota moves to foreign markets, either as commercial or food aid exports. Thus, North Dakota farmers compete for markets with farmers in other states and in other nations. Due to this situation, individual North Dakota farmers have little influence on prices received for their commodities.

Realized gross income for North Dakota farmers averaged \$10,000 in 1956 and \$18,755 in 1966. However, average production costs during the same period increased from \$6,660 to \$12,309. Net income for the period 1956 to 1966 averaged about \$4,000. However, net income was \$300 to \$1,000 below average seven years during this period. Although a slight increase in net income occurred, over 50 percent of the farmers in North Dakota still have gross sales of less than \$10,000. This amount of gross income is considered as an inadequate return to the landowner's labor, management, and capital.

Landowners in North Dakota have been and are continuing to adjust to this cost-price squeeze. One adjustment is increased crop production on existing land holdings. In 1956, 7.5 million acres were seeded to wheat and yielded 118.8 million bushels. In 1966, 6.9 million acres produced 157.7 million bushels of wheat. Fertilizer costs increased from 5.3 million dollars in 1956 to 18.5 million dollars in 1966, a 250 percent increase.

Besides increasing yields on existing acres, landowners are expanding the size of their farm units. There were 13,000 fewer farms in North Dakota in 1966 than in 1956. Eighty percent of all land transactions are for farm expansion. The greatest reduction in farm numbers has been in farms with less than 500 acres. Only farms with 1,000 acres or more are increasing in numbers.

Not only are farmers increasing production on their existing land and increasing the size of their farm units they are reclaiming noncropland acres—in this case wetlands. The desire to add more productive acres is illustrated by present rates of drainage. By 1968, North Dakota farmers had drained approximately five percent of the wetland acres that were present in 1964. The desire for drainage is further illustrated by the number of applications for cost-shared drainage. From 1962 to 1969, seven drainage seasons, Bureau of Sport Fisheries and Wildlife biologists inspected 6,079 requests for cost-shared drainage assistance.

Agricultural economists in North Dakota have stated that farmers with less than \$10,000 annual gross income (50 percent) must adjust their operations if they expect a higher family income. Higher prices for their products are not the answer (Dorow, 1967). These economists have recommended continued adjustments toward more resources per farm. This does not mean they are recommending more farm resources. This implies that not only will farmers continue to increase the size of their farm units, but will continue to increase the rate of wetland reclamation. This brief analysis of North Dakota's farm situation from the individual landowner's point of view.

NATIONAL AGRICULTURAL PHILOSOPHY

National agricultural philosophy is one of land retirement rather than increased production. The National Advisory Commission on Food and Fiber (1967) concluded that there were too many cropland acres in production in the United States. They, along with others (Mayer, Heady, and Madsen, 1968) have recommended long-term retirement and conversion of 50 to 60 million acres to less intensive uses such as grazing, forestry, and recreation. If cropland retirement increases as recommended or even continues at the present rate, it seems logical that serious consideration be given to preserving high-quality wetlands. Certainly their drainage and subsequent agricultural output defeats public benefits derived from land retirement; the primary purpose of which is reduction of crop surpluses.

As successful and essential as present wetland programs have been, it is not too early to begin formulating future programs. The Bureau of Sport Fisheries and Wildlife's wetland program will, before long, shift from one of action to repayment. Even with all goals accomplished, over one million acres of wetlands in private ownership will be vulnerable to drainage.

WATER BANK PROGRAM

An additional program is needed that has the potential of filling this gap and meeting the needs of the landowner who wishes to reclaim wetlands for increased income and those of the nation for reducing crop production. In themselves, wetlands have a wide spectrum of public values. As waterfowl production areas their value is indisputable. Where found, they also are essential to the production and survival of many upland species. Recent studies have established their importance for groundwater recharge (Eisenlohr and Sloan, 1968). The millions of wetland acres in the pothole region hold several million acre feet of spring runoff; thereby reducing flood crests. Their unique ecology makes them valuable for scientific study, natural beauty, and as a place to replenish the human spirit.

Administering Agency:

Preliminary guidelines for a water bank program are written to be financially competitive with agricultural uses of wetlands if drained. With this approach, a high degree of participation would be expected. There is no federal agency in existence with more farm contact and records than the U.S. Department of Agriculture. Therefore, it is logical for the U.S.D.A., through its county Agricultural Stabilization and Conservation Service offices, to administer the water bank program. Should this be the case, funds for the program should come from special appropriations.

Eligible Wetlands:

Considerable attention was given to what wetland types should be eligible in North Dakota. Past programs, specifically P.L. 87-732, have met with some local opposition. Many landowners are either unable or unwilling to accept biological classifications of wetlands. To avoid this problem in a water bank program, all natural, created, and restored wetlands (Types I, III, IV, and V) found in North Dakota would be eligible. If certain wetland types were restricted there would be additional administrative costs involved in classifying wetland types. Money for such costs could be used to greater advantage for higher landowner payments to insure maximum preservation. In other states, certain wetlands or geographical areas would have to be excluded. This authority must remain at the state level.

Artificial water areas, such as stock dams, would be eligible for a water bank program. However, these water areas must be managed as multi-purpose impoundments. A watering facility managed to provide for wildlife production, flood control, and erosion control would qualify. More detailed determinations of eligibility would be necessary for these areas.

Program Options:

For North Dakota, wetlands have been classified according to whether they are located in cropland or in noncropland rangeland. Within these categories, farmers would have the choice of (1) a use option under which they would receive an annual payment for not draining, filling, or burning the wetland basin. They would retain normal crop production, haying, or grazing use as weather conditions permitted. Landowners could (2) place their wetlands under a nonuse option and forego any agricultural use in addition to not draining, filling, or burning. A higher payment rate would be available for foregoing agricultural income.

Landowners who have wetlands covered by a Bureau of Sport Fisheries and Wildlife easement would be eligible for the proposed water bank program. By signing an easement agreement with the Bureau, the landowner has received some financial compensation for his right to drain, fill, or burn his wetlands. He does, however, retain all other agricultural uses. One possible approach would be to reduce the Bureau easement payment to an annual value which would be deducted from an annual water bank payment. Actual deductions of easement payments would have to be determined by the Secretary and included in program administrative guidelines.

Buffer Zones:

Landowners selecting a nonuse option could retire a portion of the upland adjacent to the wetlands. Maximum upland retired could be three acres for each one acre of wetland under contract. Retired upland must be planted to an approved cover and maintained throughout the length of the contract. If in noncropland, the wetland and retired upland must be fenced. Payments for retired upland would be at the full nonuse rate regardless of whether the wetland was under Bureau easement or not. Thus, with a Bureau easement, wetland acre payments would be at a somewhat reduced rate while the upland would qualify for the full payment rate.

Public Access:

Landowners could receive an additional payment per acre for allowing public access. Public access payments would be restricted to wetland and adjacent, retired upland acres under nonuse options. Preliminary discussions in other states indicate that not all states would accept the public access provision. Thus, this authority should remain at the state level.

Contract Length:

A water bank program, while it has certain features of a land retirement program, is basically designed to preserve and maintain the wetland resource and its associated values over a long period of time. There is no indication that the wide spectrum of wetland values will decrease in the future. Neither is there reason to assume that the competitive nature of farming will decrease. This being the case, both wetland values and threats of drainage will increase. A water bank program, if suddenly terminated or inadequately financed, could place the wetland resource in serious jeopardy. Therefore, it is absolutely essential that the program be *continuous*. It is critical that the problems of funding encountered in the Cropland Adjustment Program not be repeated in a Water Bank Program!

Assuming a continuous program, 10-year contracts have been proposed in North Dakota. This, if the program is continuous, could provide flexibility in program procedures and periodic payment adjustment. Regardless of contract length, payment rate adjustments are necessary to maintain a financially competitive program. Upon expiration of a 10-year contract, the landowner could then enter another 10-year contract. Longer contract lengths have been recommended by other states contacted. Preliminary work in Minnesota on a water bank proposal has resulted in recommendations for contract lengths of 10, 20, 30, or 40 years—the decision to be left to the landowners.

Payment Rates:

Full payment rates for wetland acres in cropland and adjacent, retired upland would be based on the average county crop production base and adjusted to the productivity index of the particular farm under contract. County and farm production rates are presently calculated and on file in all county ASCS offices. This payment rate, adjusted by county and farm, would apply to cropland wetlands where the landowner contracted for the nonuse option. Landowners choosing a use option would be paid a reduced amount since they would retain agricultural income. This approach is necessary since payment rates must be competitive regardless of soil capabilities or the operator's management efficiency.

Payment rates for wetlands in noncropland would be based on the statewide average for grazing fees plus a specified amount for contracting not to drain, fill, or burn. Payment rates would be the same statewide. This payment would apply to wetlands under a nonuse option. Landowners choosing a use option would be paid only for not draining, filling, or burning.

It would be possible for an individual farmer or rancher to have cropland and noncropland wetlands under use and nonuse options. The variety of wetlands and combination of contracts are impossible to predict. Certain assumptions seem valid: (1) a minority of landowners would select a nonuse option for temporary cropland wetlands (Type I); (2) use and nonuse options would be about 50-50 for semi-permanent cropland wetlands (Type III); (3) the majority of landowners would select a nonuse option for cropland wetland areas that are permanent (Types IV and V); and (4) the majority of landowners would choose a use option for all types of noncropland wetlands. Thus, in cropland, the fewer years out of 10 a landowner is able to farm the wetland the more likely he is to choose a nonuse option. Also, since wetlands in noncropland are generally a source of pasture, emergency hay, and water for cattle, landowners are less likely to choose a nonuse option which would require fencing regardless of the wetland type.

REACTIONS TO THE WATER BANK

Some progress has been made to date on furthering the proposed water bank program. Following completion of preliminary water bank guidelines, representatives of the North Dakota Wildlife Advisory Committee held meetings in Montana, South Dakota, and Minnesota in June, 1968. Persons attending these meetings represented state and federal agricultural and wildlife agencies, farm organizations, livestock growers, and private wildlife interests. The North Dakota water bank proposal was reviewed with them. A final draft of the North

Dakota proposal was then completed by the Advisory Committee and presented to North Dakota's Congressional Delegation in November, 1968. Their reaction was extremely favorable. Representative Kleppe and Senator Burdick agreed to draft a preliminary bill for review by the North Dakota Committee. Following the meeting with the North Dakota Congressional Delegation, letters were sent to wildlife and agricultural agencies in Montana, South Dakota, and Minnesota, informing them of the progress to date and extending an invitation to have their agencies represented when the North Dakota Wildlife Advisory Committee met to review the bills. These bills have been returned to North Dakota and reviewed.

At the present time there is no definite legislative time schedule. Certainly, a number of years may be involved in developing a suitable program that will accomplish the desired results and adequately serve all interests. When the Bureau program converts from one of action to repayment, it is essential that a new funded program be ready to insure maximum preservation of the wetland resource.

LITERATURE CITED

Barlowe, R.
1958. Land resource economics. Prentice-Hall, Inc. Englewood Cliffs, N. J. 585 pp.

Dorow, N. A.
1967. North Dakota's agriculture. N. D. Coop. Ext. Serv. Summer Conf. N. D. State Univ. 26 pp.

Eisenlohr, W. C. and C. E. Sloan
1968. Generalized hydrology of prairie potholes on the Coteau du Missouri, North Dakota. Geological Survey Circular 558. U.S. Govt. Printing off. 12 pp.

Mayer, L. V., E. O. Heady, and H. C. Madsen
1968. Farm programs for the 1970's. Iowa State Univ. CAED Rept. No. 32. 60 pp.

National Advisory Commission on Food and Fiber
1967. Food and fiber for the future. U.S. Govt. Printing Off. 161 pp.

DISCUSSION

MR. LARRY R. GALE (Missouri): This concept has considerable promise for solving many of our problems. One thing I am wondering about is actual cost. Do you have any estimates of the total payments that might be required on lands that were under Bureau easements as well as water banks and how this total cost might compare with the actual purchase price of the land if it were for sale?

MR. HARMON: I can give you some figures we computed for North Dakota. You can recognize the fact that the more temporary the wetland area is, the more likely the landowner would be to take a use option and retain that agricultural income. In other words, we do have a variety of situations and options. We buy some on the basis of participation by individuals involved and figuring 100 percent participation in the program. Also considering the Bureau easement payments we could be talkng about a $10 million a year figure in North Dakota alone. This is not an extremely large amount of money, because presently we are paying over $10 million for the feed-grain program and the Cropland Adjustment Program within the state. During the soil bank years, annual payments were as high as $25 million.

On how much it would cost to purchase these areas, I cannot give you a figure. The only thing I can tell you is, in relation to land acquisition, you simply cannot purchase a million acres of wetlands in North Dakota. The counties would not stand for it.

DR. ALEX CRINGAN (Colorado and Ontario): In view of the reduced wetland areas we now have, is there any hope of a significant increase in waterfowl production unless, of course, they can be managed extensively enough to increase production? From the development that you have carrier out so far, how optimistic are you as to the prospects of significant increases in waterfowl production on these reduced resource lands?

MR. HARMON: The only answer I can give would be the feature of land retirement around the wetland areas, which are now presently being extensively used for crop production. The North Dakota Committee feels that this would be initially a great benefit to waterfowl production. Whether we can have features in this program for extensive waterfowl management on the wetland acres themselves, I don't know. I have been involved in a number of committee meetings there, along with some other people here, trying to get action on wetland practices in watersheds where certain acreages of wetlands have been lost. I am sorry to say that after 30-some years of waterfowl research we do not now know how to replace the loss of Type III wetlands.

DR. ROY TULANE (Wisconsin): There was a man in Los Angeles who had a brickyard. When the need of the community demanded that there be no brickyard in Los Angeles, the City exercised its police power and told him he should not run it. Now, by the same token, when the needs of the communities with regard to the preservation of wetland and the needs of the people who follow the ducks that inhabit wetlands come to the point where we tell him that he shall not drain, will this have an effect?

MR. HARMON: I don't know that I can answer that. However, the fact remains that wetland resources are in private lands, and this again is a matter of public welfare and economics. When you have public values represented on private lands and it becomes a financial obligation of the landowner to retain that wetland, it is also the obligation of society to pick up the bill. This in effect is what we are talking about as the water bank program. Further, we can philosophize waterfowl hunting and the duck population right out of the United States.

MR. RETTINGER: This is an ambitious subject, and very important. The people from North Dakota are really up on this subject. These last two papers have brought to light the economic value of wetlands and the problems associated with them. Isn't it time we took a realistic attitude and attempted to instigate more action nationwide to overcome this situation? We can no longer live with the present stumbling blocks. Just how long can we be philosophical?

CROP INSURANCE FOR WATERFOWL DEPREDATION

ROBERT E. FARMES
Department of Conservation, Thief River Falls, Minnesota

"In these days of waterfowl scarcity, when Federal, State and local agencies entrusted with the conservation of wildlife are practically unanimous in the opinion that the wild fowl of North America are in a precarious condition and that some species are possibly in danger of extermination, it may seem strange that suggestions for the reduction of damage by them are called for."

This statement was made in 1935 by E. R. Kalmbach in the introduction to a leaflet published by the Bureau of Biological Survey (Kalmbach, 1935). More than 33 years have elapsed, and yet this statement is equally applicable today.

In those years considerable attention has been given to the waterfowl depredations problem. Numerous writers have given accounts of depredation problems in a number of areas and many have written about various control techniques. The problem is so well known, as are the various techniques of feeding and scaring, that they will not be reviewed here.

Despite the fact that a great deal has been done to alleviate the problem in certain areas, depredations by waterfowl are still an almost annual occurrence in some areas and each year more and more farmers are getting a taste of waterfowl damage to their crops.

The seriousness of the problem has been stated time and time again. Day (1944) in his review of the problem said that if government agencies do not reduce crop damages to a reasonable level, farmers would feel justified in applying whatever remedies they could. Leitch (1951) in discussing waterfowl management in western Canada considered a solution to the duck depredation problem an *urgent need.* Munro and Gollop (1955) speaking of the same area felt that crop damage was *the limiting factor* and *the major land-use problem* on the breeding grounds. Bossenmaier and Marshall (1958) recognized that waterfowl programs suffer as long as they grossly conflict with agriculture and spoke of a *moral obligation.* More recently Hammond (1964) has said, "The small grain farmer holds the future of waterfowl in the palm of his calloused hand. At times he is in the mood to throw it away. Hordes of ducks gorge on his fall crops. Sometimes they trample more than they eat. Hunters in pursuit of grain-fed ducks may scatter his swaths, leave his gates open, throw away beer cans to pass through his combine, and thumb their noses at him if he protests their carelessness. No wonder the western grain farmer has reservations about the value of waterfowl."

In recognition of the seriousness of the problem in Minnesota the legislature made a study of the problem and issued a special report of duck depredation in northwestern Minnesota (M.O.R.R.C. 1967).

In the early 1960's a waterfowl depredations control committee was formed in Minnesota to coordinate the control activities between the Minnesota Division of Game and Fish and the Bureau of Sport Fisheries and Wildlife. Depredations problems are common in a two county area in northwestern Minnesota where the State Roseau River and Thief Lake Wildlife Management Areas and the Agassiz National Wildlife Refuge are located. As a result of the formation of this committee both the State and the Federal agencies have taken a more positive role in trying to control the problem. This program consists of feeding on the major wildlife areas together with scaring on private lands.

While these measures have done a great deal to help alleviate the problem, the committee believes that if the average grain farmer is going to look upon ducks as something more than pests, more has to be done. In search of new ideas, the committee has expanded to include the Soil Conservation Service, Agricultural Stabilization and Conservation Service, Federal Crop Insurance Corporation and the University of Minnesota Extension Service. In addition, Bureau of Sport Fisheries and Wildlife personnel from North Dakota with considerable experience in depredations work including personnel from the Northern Prairie Wildlife Research Center joined the group.

Discussions at these expanded committee meetings have involved such things as the various feeding and scaring techniques, methods of harvesting crops, possible new crops or new crop varieties and direct payments for losses including an insurance program. It was generally agreed that research efforts should be directed primarily at developing methods of avoidance rather than by developing new and better techniques of combative action.

Through the efforts of the depredations control committee, a special Agricultural Conservation Practice was adopted by the Agricultural Stabilization and Conservation Service aimed at alleviating the waterfowl depredation problem. Limited to one county on a trial basis, it provides for small grain plantings of 10 acres per 160 acres of ownership to be left in the field until all other grain in the area is harvested. To date too few farmers have adopted the practice to evaluate it.

CONCLUSIONS

Most committee members believed that the idea of an insurance program needed further exploration. Thus an insurance subcommittee was formed. Discussions at these meetings together with the regular committee meetings have led to the following conclusions:

1. The future success of waterfowl management programs and habitat preservation and acquisition of wildlife areas in Minnesota and North Dakota as well as in other states may be dependent upon a satisfactory solution to the depredations problem. Wildlife people engaged in waterfowl habitat preservation programs agree that a satisfactory solution would materially advance these programs.

2. As wildlife land acquisition and management by the States and the Federal Government is expanded, farmers are more closely able to identify the source of depredating ducks with government ownership.

3. Although past court decisions have absolved the Federal Government from waterfowl crop damage claims, State of Minnesota claims have not been resolved and there is uncertainty as to federal and state court actions under certain potential crop loss conditions. Both federal and state agencies have, in fact, assumed certain responsibilities, particularly around purchased, developed and managed areas.

4. The extent of farmer willingness to contribute money and labor toward crop protection varies widely. It is determined largely by individual "social" attitude (his willingness to contribute to the waterfowl resource), his expectations of some economic or esthetic return through hunting or enjoyment of waterfowl sights and sounds, and the immediate threat of irrecoverable loss. Some farmers believe that the entire responsibility for control rests with the government.

5. There are wide differences of opinion among wildlife people themselves as to the extent of government responsibility for control. The Central Flyway Waterfowl Management Plan discusses responsibility for control of waterfowl damage and states that:

> "In the absence of either sanctuary or food supply, there would be no problem. With both, the problem may become grave, and responsibility for control of damage is usually the responsibility of Federal and State game agencies. In instances where such agencies are responsible through land acquisition and development they should accept the responsibility of alleviating damage."

6. With these wide extremes of opinion about responsibility now present, a compromise level must be reached. We believe that an insurance program can offer this compromise.

7. Existing Federal Crop Insurance or private insurance policies do not offer coverage to meet the need. The Federal Crop Insurance Corporation, which is an agency of the U.S. Department of Agriculture, insures against all the hazards of nature including wildlife. However a farmer cannot start collecting under this program until a certain percentage of his crop is already lost. Basically, this program is designed to pay only the investment in the crop. ***Thus insurance for wildlife damages is already available from the Federal Government,***

but we believe that changes are needed in the case of waterfowl depredations.

The Province of Saskatchewan has had a wildlife crop damage insurance program since 1953. For a 2 percent premium small grains are insured against damage by waterfowl, cranes, and big game. Coverage is offered in multiples of $5 an acre to a maximum of $25. The program is administered by the Saskatchewan Government Insurance Office and financed by a $1 surcharge on hunting licenses together with the premium payments. Premiums just about cover the cost of administration, and most crop losses are paid from the surcharge. The program has been well accepted (Klassen, 1969). In 1966, 824 farmers were insured for a total of $2,509,102. Premiums paid amounted to $51,506 and losses paid were $148,118 (Paynter, undated).

PROPOSAL

Until better control of waterfowl depredations can be accomplished, we propose that a pilot or experimental insurance package designed after the Saskatchewan plan be made available. It should be limited to one particular problem area such as northwestern Minnesota until a satisfactory plan has been developed. Then it should be made available nationally. While the details of operation should be determined by insurance experts with the help of knowledgeable wildlife people, certain aspects of such a program have been discussed by the waterfowl depredations committee.

The plan must have premiums low enough so that it will be readily acceptable by farmers within the potential crop damage area. This means that a major portion of the cost will have to be borne by a government agency. A premium rate and coverage similar to the Saskatchewan program appears practical in Minnesota.

The plan must leave the farmer with an acceptable level of responsibility so that he will devote a reasonable expenditure of time and funds to the control effort. That is, he would stand to gain economically by putting forth a reasonable effort at crop protection. The pilot program would determine this "reasonable level."

A farmer should probably be required to insure all his acreage of a susceptible crop if he participated. This might help to prevent certain types of questionable farming practices just to collect insurance.

Farmers could collect for any significant waterfowl-caused losses up to a suggested limit of $20 per acre in Minnesota. Since most small grain crops are worth more than this, farmers should still be interested in controlling losses. Maximum coverages should be adjusted according to area and based on the value of the crop.

The Federal Crop Insurance Corporation has the background and experience plus most of the field force necessary to handle such a program. State Federal Crop Insurance personnel are interested in such a program and believe that authorization to handle a pilot program could be made through an amendment to existing laws.

SOURCE OF FUNDS

A capital indemnity fund and annual funds to maintain its level could come from one of several sources:

1. An annual federal appropriation from general revenue funds is believed to be the most preferable because of the national scope of the problem and because the Federal Government is charged with the responsibility of waterfowl management.
2. Duck stamp moneys are a possible source of funds although it is believed they should not carry the full burden—if used at all. Many people in addition to duck stamp purchasers have a stake in the waterfowl resource.
3. States might contribute to the fund, but because of the national scope of the problem and the federal responsibility, federal funds should bear the major expense.

JUSTIFICATION

The obvious question to be raised here is why should crop insurance be made available for losses due to waterfowl and not the many other game and non-game birds and mammals that cause economic hardship? Waterfowl management by both the Federal Government and many state agencies has become both so extensive and intensive that their responsibilities for problems caused by this resource are greater. The waterfowl depredation problem is a serious deterrent to accomplishing these management objectives.

The success of such a program should not be judged solely by the number of participants, or by benefits distributed. A general improvement in farmer attitudes toward waterfowl management would be an important contribution. Until this improvement of farmer and local agricultural interests is obtained, waterfowl management programs will never have the support essential to carry out these programs. Hammond (1964), I believe, expresses our thoughts when he offers this suggestion: "This country has a surplus of one crop (grain) and a shortage of another crop (ducks). Payments to farmers, for concessions and operations in behalf of migratory waterfowl, may well prove rewarding to this grain-rich, recreation hungry Nation.

ACKNOWLEDGMENTS

I wish to express my thanks to the members of the Minnesota waterfowl depredations control committee and especially the insurance sub-committee. I want to give special thanks to Merrill C. Hammond, Bureau of Sport Fisheries and Wildlife, for his help in developing this paper. Special credit should be given to Herbert H. Dill, Bureau of Sport Fisheries and Wildlife, for initiating efforts to form the waterfowl depredations control committee and for leadership through the first years of operation.

LITERATURE CITED

Bossenmaier, Eugene F., and William H. Marshall
1958. Field-feeding by waterfowl in southeastern Manitoba. Wildlife Monographs No. I.

Day, Albert M.
1944. Control of waterfowl depredations. Trans. N. A. Wildl. Conf. 9:281-287

Hammond, Merrill C.
1964. Ducks, grain, and American farmers. Waterfowl Tomorrow. pages 417-424.

Kalmbach, E. R.
1935. Protecting grain crops from damage by wild fowl. Wildl. Research and Mgmt. Leaflet BS-13.

Klassen, W. A.
1969. Personal communication.

Leitch, William G.
1951. Saving, maintaining, and developing waterfowl habitat in western Canada. Trans. N. A. Wildl. Conf. 16:94-99.

Minnesota Outdoor Recreation Resources Commission
1967. Duck depredation in northwestern Minnesota. Staff Report No. 13.

Munro, David A., and J. Bernard Gollop
1955. Canada's place in flyway management. Trans. N. A. Wildl. Conf. 20:118-125.

Paynter, E. L.
Undated. Crop insurance. Typewritten manuscript. 3 pp.

THE KILLING EFFICIENCY OF SOFT IRON SHOT

RALPH ANDREWS AND JERRY R. LONGCORE
Bureau of Sport Fisheries and Wildlife, Patuxent Wildlife Research Center, Laurel, Maryland

The problem of lead poisoning needs little introduction to conservationists concerned about dwindling populations of wild waterfowl and the perpetuation of wildfowling. For more than a century, it has been known that waterfowl will die after ingesting lead shot picked up from the bottoms of shallow lakes, ponds, and marshes. Major losses have been well documented for nearly four decades, but most waterfowl that die from lead poisoning are probably never noted. The annual mortality due to this malady is difficult to estimate but may amount to a wastage of nearly a million North American ducks, geese, and swans in some years. Most of these birds succumb after the hunting season and represent a loss of potential breeders. The possibility for increased losses mounts, as some 6,000 tons of spent shot are deposited on waterfowl habitat each year. Fortunately, most shot settles in deep water or soft bottoms out of the reach of waterfowl, but much accumulates on hard, shallow bottoms of our diminishing wetlands.

The need for a solution to the lead poisoning problem has been recognized by both conservationists and the ammunition industry for many years. As early as 1936 there was an attempt to solve the problem by making a shot of lead-magnesium alloy that would disintegrate in water. In the early 1950's, a study launched by the Illinois Natural History Survey and supported by the Olin Mathieson Chemical Corporation resulted in a bulletin by Frank C. Bellrose (1959) entitled, "Lead poisoning as a mortality factor in waterfowl populations." Bellrose not only provided a thorough analysis of the problem but pioneered in the search for a solution. He concluded that the solution depended on development of a non-toxic substitute for lead shot. One of several candidates that he tested was an annealed iron shot, produced by Olin Mathieson under a proprietary process. That process was not feasible for large-scale production, and the laboratory which developed it is no longer in existence. However, Bellrose conducted some limited shooting tests with iron shot produced by the process and found that it was almost as effective as lead shot at ranges up to 50 yards. He concluded: "Should lead poisoning become a more serious menace to waterfowl populations, iron shot provides a possible means of overcoming it."

Several years later, the Mississippi Flyway Council (1965) recommended an action program to reduce waste in waterfowl populations and thereby make more birds available for recreation. The lead poisoning problem was given top priority and received an updated review in the publication, *Wasted Waterfowl.* Included in that report were the results of a comparative field testing of iron and lead shot. The test indicated that Number 2 iron shot would kill ducks as readily as Number 4 lead shot at ranges up to 40 yards and might result in fewer cripples.

In the fall of 1966, the Sporting Arms and Ammunition Manufacturers' Institute (SAAMI) and the Bureau of Sport Fisheries and Wildlife initiated a cooperative research effort to solve the vexing problem of waterfowl poisoning caused by ingested lead shot. SAAMI financed a $100,000, 2-year study by the Illinois Institute of Technology (IIT)—one of the nation's outstanding technical research organizations—to find and develop a suitable substitute for lead shot. Promising candidates were to be tested for possible toxic effects by the Bureau's Patuxent Wildlife Research Center. Efforts by IIT to render lead nontoxic with biochemical additives were unsuccessful, and a thorough review of lead alloys, protective coatings, and disintegrating shot also proved unproductive. Again, the only promising candidate was soft iron.

Despite the fact that iron is the nearest practical substitute for lead, it has been considered a rather poor replacement because of certain inadequacies. As Baker (1966) pointed out, lead is well suited for shot-making in all respects except toxicity. It has the high density needed for maximum velocity and energy retention; is relatively low in cost; is easily processed; is soft enough to preclude damage to gun barrels and chokes; and is relatively inert. Iron has a density of 0.28 lbs./cu. in. as compared to 0.41 lbs./cu. in. for lead. Iron is inexpensive in its raw form, but processing costs are high, and shot produced from it are normally so hard that gun barrels and chokes are damaged. Protective liners or coated shot can minimize barrel scratching, but choke deformation still occurs. Softness can be achieved by repeated annealing, but this increases the cost. Above all, however, iron has been considered a poor substitute because its low density would presumably result in performance shortcomings—particularly at ranges of more than 40 yards.

When the research by IIT indicated that soft iron shot was the best remaining substitute, plans were made for a thorough testing of the capability of iron to kill ducks at various distances. Engineers from SAAMI and biologists from the Patuxent Wildlife Research Center cooperatively designed and constructed a shooting facility and testing program to compare the killing efficiencies of various shot loads under carefully controlled conditions.

This paper summarizes the principal findings of that testing program.

METHODS AND MATERIALS

Guns and ammunition for the test were provided by SAAMI. A 12-gauge pump shotgun with 30-inch, full choke barrel was used. Additional barrels were provided and used during the test. These barrels were pretested to determine their pattern performance, and each barrel was retired after a prescribed amount of firing. Commercial 12-gauge 2¾″ 1¼ ounce lead loads in Number 4 and Number 6 shot sizes were used as standards for comparison.

The ammunition industry produced 1000 pounds of Number 4 iron shot from low carbon, super-soft wire, utilizing a process that produces air-rifle shot. Due to work hardness, the shot were subsequently annealed to provide a nominal external hardness of 65 DPH. This was soft enough to preclude the excessive barrel damage experienced with other iron shot although ultimate choke damage was not entirely prevented. The ammunition industry provided loaded rounds which would deliver the best possible performance. These maximum-weight, 1-ounce iron loads contained about 180 pellets, the same number as the 1¼-ounce loads of Number 4 lead shot. The 1¼-ounce loads of Number 6 lead shot averaged about 300 pellets. The iron shot were surrounded by a polyethylene liner 0.020 inches thick to provide added protection to the barrel. A slow-burning ball powder provided maximum muzzle velocity.

A unique duck-transport device was engineered by the ammunition industry and constructed at the Patuxent Wildlife Research Center. This automated shooting device moved a tethered, wing-flapping duck across a point where the mounted, preaimed gun fired a "perfect" shot. The system consisted of a cable-pulled carriage on a 75-ft. set of tracks. An electric motor, through gear reduction and clutch-brake units, accelerated the carriage to about 20 mph at the shooting position. Ducks were tethered to an adjustable rod mounted on the carriage and shaped as an inverted "J". A close simulation of a free-flying duck, passing a shooting position, was achieved. The shotgun was mounted on a movable wooden "horse" and triggered by a solenoid activated through a microswitch. Other microswitches braked the carriage on forward and return trips. A movable control box for the entire facility was positioned beside the gun mount. Sighting stakes were erected for each shooting distance so that the gun could be accurately aimed prior to each shot. Standard 30-inch targets were shot to locate center of patterns and determine positions of sighting stakes. The targets were also used to assure that ducks were centered in the pattern prior to each day of shooting.

Game-farm mallards of uniform age and closely similar to wild birds in appearance and weight were used for this test. Equal numbers of drakes and hens were individually weighed and banded.

The experiment utilized a split plot design wherein shooting distances comprised the whole plots, and combinations of shot types and sex, arranged factorially, comprised the subplots. Ducks were shot in sets of five for a given combination of factors. The initial test design called for 900 ducks to be shot at ranges of 30, 40, and 50 yards. When it became evident that all shot loads were extremely effective at 30 yards and that iron performed well at 50 yards, the 30-yard position was discontinued and a 60-yard position was added. The ducks in that test were shot from a broadside position and an elevation angle of about 15°. Subsequently, 300 more ducks were shot from a nearly head-on direction at ranges of 40 and 50 yards. The testing was started in March, 1968, and concluded in June. After the results were tabulated and examined, additional data for intermediate distances seemed desirable; therefore, a supplementary test at ranges of 45, 55, and 65 yards was conducted in November-December, 1968. The results of these three tests are summarized together in the accompanying tables, although they have been evaluated statistically as separate entities.

The fate of each duck was recorded either in one of four kill categories or as a survivor. The kill categories were: (1) instant (within 1 minute), (2) 1 minute to 5 minutes, (3) 5 minutes to 1 day, and (4) 1 day to 10 days. All ducks alive at the end of a shooting day were held for 10 days in pens with food and water. Those alive after 10 days were killed with carbon monoxide. All carcasses were weighed, examined for broken wing and leg bones and fluoroscoped to obtain counts of embedded shot. A representative sample of ducks (630) was defeathered to obtain counts of entrance and exit wounds.

RESULTS

Table 1 depicts the results in categories which are based on timed intervals after shooting. These categories provide an objective basis for comparing the killing effectiveness of the three shot types. However, they cannot be directly translated to hunting success in the field, where a duck is either bagged, crippled and lost, or "missed."

TABLE 1.—KILLING EFFICIENCIES OF THREE SHOT TYPES EXPRESSED AS PERCENTAGES OF DUCKS IN TIMED KILL CATEGORIES.

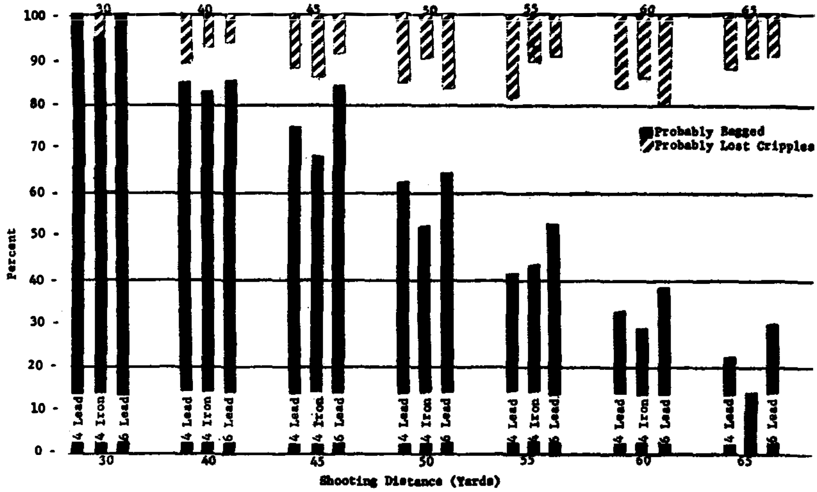
			Number 4 Lead					Number 4 Iron					Number 6 Lead				
Shooting Distance (Yards)	Total Ducks Shot	Sample for each Shot Type	Instant Kill*	1-5 Minutes	5 Minutes - 1 Day	1-10 Days	Survivors	Instant Kill	1-5 Minutes	5 Minutes - 1 Day	1-10 Days	Survivors	Instant Kill	1-5 Minutes	5 Minutes - 1 Day	1-10 Days	Survivors
Broadside																	
30	60	20	95	5	0	0	0	90	0	10	0	0	95	5	0	0	0
40	300	100	66	9	17	0	8	69	2	11	5	13	71	2	13	3	11
45	300	100	52	12	12	5	19	36	16	14	5	29	53	14	16	3	14
50	300	100	38	11	13	7	31	34	3	6	6	51	44	5	16	8	27
55	300	100	21	8	15	6	50	16	8	3	5	68	24	4	7	5	60
60	150	50	18	6	20	0	56	12	6	10	2	70	24	10	16	2	48
65	300	100	6	4	8	3	79	4	2	4	4	86	13	2	10	0	75
Head-on																	
40	150	50	46	6	22	4	22	48	8	6	4	34	48	20	22	0	10
50	150	50	20	8	16	2	54	14	10	14	2	60	8	8	12	4	68

* Death within 1 minute.

These categories also fail to take account of the probable fate of ducks with broken wings. Bellrose (1953) noted that ". . . the fracturing of a wing bone was the most important single type of wound resulting in the bagging of ducks."

Therefore, in Table 2, all ducks which died within 5 minutes plus those with at least one broken wing bone are grouped as "probably bagged." Those without broken wings are considered "lost cripples" if they died between 5 minutes and 10 days after shooting, and "survivors" if in apparent good health after 10 days. Figure 1 compares the performances of the three shot types at all broadside ranges.

Figure 1—Percentages of ducks probably "bagged" or "crippled and lost" as a result of shooting with three shot types at broadside distances of 30-65 yards.



Statistical evaluation of the three tests, by analysis of variance, failed to establish differences at the 5 percent level of significance between the performance of Number 4 iron shot and Number 4 lead shot, either in terms of ducks "probably bagged" or ducks "crippled and lost." Shooting distance provided the only highly significant effect on the percentages of ducks "probably bagged" ($P=.01$). There were no discernible differences in vulnerability between hens and drakes.

TABLE 2.—PERCENTAGES OF DUCKS BAGGED BY THREE SHOT TYPES WITH ADJUSTMENT FOR WING BREAKAGE.

		Percentage of ducks bagged, based on death within 5 minutes			Percentage of ducks with a broken wing			Percentage of ducks with broken wing and alive after 5 minutes			Percentage of ducks bagged, based on death within 5 minutes or broken wing		
Shooting Distance (Yards)	Sample Size for each Shot Type	#4 Lead	#4 Iron	#6 Lead	#4 Lead	#4 Iron	#6 Lead	#4 Lead	#4 Iron	#6 Dead	#4 Lead	#4 Iron	#6 Lead
Broadside													
30	20	100	90	100	80	75	85	0	5	0	100	95	100
40	100	75	71	73	47	49	57	10	12	13	85	83	86
45	100	64	52	67	33	38	47	11	16	17	75	68	84
50	100	49	37	49	25	22	26	13	15	14	62	52	63
55	100	29	24	28	15	22	28	12	19	24	41	43	52
60	50	24	18	34	12	12	12	8	10	4	32	28	38
65	100	10	6	15	12	8	15	12	8	14	22	14	29
Head-on													
40	50	52	56	68	68	64	74	34	30	24	86	86	92
50	50	28	24	16	42	38	50	22	26	40	50	50	56

DISCUSSION

Ballistic studies have shown that the lower pellet weight of iron shot will result in a higher deceleration rate that cannot be overcome by raising muzzle velocity (Baker, 1966). Since the low-density iron shot lose energy more rapidly, it has always been assumed that they were less effective at longer ranges. This assumption has been based on the fact that a pellet needs sufficient energy to penetrate a vital area of the duck. This is obviously true, but the required threshold seems to be much lower than has been assumed. Our tests showed that the killing effectiveness of this soft iron shot was greater than anticipated.

The same reasoning has led to the assumption that at longer ranges Number 4 lead shot was more effective than the smaller Number 6 lead shot. Bellrose (1953) noted that Number 4 shot became increasingly more effective than Number 6 shot as ranges increased beyond 35 yards and attributed the superiority to a greater striking force. Our tests indicated that Number 6 lead shot was slightly more effective in bagging ducks than either type of Number 4 shot ($P = .05$). This apparent superiority of the Number 6 lead loads probably resulted because the greater number of pellets per load increased the probability of at least one pellet striking a vital area.

Our study failed to indicate that Number 4 lead shot would bag mallard ducks more effectively than Number 4 iron shot. Although the percentages of ducks "probably bagged" were numerically slightly higher for the lead shot in broadside shooting for six of seven distances (Figure 1), such an event would be expected more than 12 percent of the time by chance alone if the shot types were in fact identical. In head-on shooting at ranges of 40 and 50 yards, the performances of the two Number 4 shot loads were virtually equal (Table 2).

Some have surmised that iron shot would result in a greater loss of unretrieved cripples. The Nilo Farms test conducted by the Mississippi Flyway Council (1965) suggested that on the contrary, crippling loss would actually be less with iron shot. Our tests indicated that the use of iron shot did not increase or decrease crippling loss.

The probability of bagging a duck, as defined in this test, is a function of range for any given shot type. In other words, the pattern density and, therefore, the probability of a shot pellet striking a vital area on the duck, decreases as range increases. In our test, the likelihood of "bagging" a perfectly centered duck decreased to less than 50 percent as range increased beyond 50 yards. This supports the frequently voiced admonition to duck hunters: "Let them come close before you shoot."

The killing effectiveness of the soft iron shot used in this test provides some hope for an eventual solution to the lead poisoning problem in waterfowl. Unfortunately, there are some major obstacles to be surmounted before a transition to iron shot is possible. The soft iron shot used in this test was produced by industry on a laboratory basis that was slow, costly, and totally unsuitable for large-scale production. No economic process for the manufacture of soft iron shot is now known. SAAMI is sponsoring the development of such a process by IIT and is also exploring other approaches to the problem. Even after a process has been found, the construction of facilities, procurement of equipment, and other matters will remain before iron shot becomes available for loading.

SUMMARY

A cooperative research effort between the ammunition industry and the Bureau of Sport Fisheries and Wildlife is aimed at finding a suitable non-toxic substitute for lead shot. A contract study by an independent research organization evaluated ways of coating or detoxifying lead shot or replacing it with another metal. As a result of that study, the only promising candidate is soft iron. Previous tests of hard iron shot had suggested that its killing effectiveness was poor at longer ranges due to the lower density. In addition, its hardness caused excessive damage to shotgun barrels.

A unique, automated shooting facility was constructed at the Patuxent Wildlife Research Center to test the killing effectiveness of soft iron shot under controlled conditions. Tethered game-farm mallards were transported across a shooting point in a manner simulating free flight. A microswitch triggered a mounted shotgun so that each shot was "perfect." A soft iron shot, in Number 4 size, was produced by the ammunition industry and loaded in 12-gauge shells to give optimum ballistic performance. Commercial loads of lead shot in both Number 4 and Number 6 size were used for comparison. A total of 2,010 ducks were shot at ranges of 30 to 65 yards and at broadside and head-on angles in a statistically designed procedure. The following data were recorded for each duck: time until death, broken wing or leg bones, and number of embedded shot. Those ducks not killed outright were held for 10 days. From these data, ducks were categorized as "probably bagged," "probably lost cripples," or survivors.

The test revealed that the killing effectiveness of this soft iron shot was superior to its anticipated performance and close to that obtained with commercial lead loads containing an equal number of pellets. Bagging a duck, in terms of rapid death or broken wing, was primarily dependent on the probability of a shot striking that vital

area, and therefore a function of range. There was no indication that iron shot would result in greater crippling loss.

Despite the apparent effectiveness of this iron shot, transition to its use in waterfowl hunting is not now possible. The sample used for this test was produced by a laboratory procedure that is unsuitable for manufacture. There is no process for producing soft iron shot in the quantities needed. Industry is doing its best to resolve this problem.

ACKNOWLEDGMENTS

The assistance of many individuals contributed to the accomplishment of this work. The equipment and advice provided by members of the SAAMI non-toxic shot committee were essential to its success. Mr. Robert G. Heath, biometrician of the Patuxent Wildlife Research Center, Bureau of Sport Fisheries and Wildlife, provided guidance in designing the test procedure and analyzed the results.

LITERATURE CITED

Baker, J. G.
1966. The industrial status of lead shot substitutes. Trans. N. Amer. Wildl. Conf. 31:97-103.

Bellrose, Frank C.
1953. A preliminary evaluation of cripple losses in waterfowl. Trans. N. Amer. Wildl. Conf. 18:337-360.

————————.
1959. Lead poisoning as a mortality factor in waterfowl populations. Bull. Ill. Nat. Hist. Surv. 27(3):235-288.

Mississippi Flyway Council, Planning Committee.
1965. Wasted Waterfowl: progress report on lead poisoning investigations. 84 p.

DISCUSSION

MR. TOM EVANS (Illinois): Are you in a position to say what the industry appraisal of the effectiveness is? Do you feel that there is enough information with regard to iron shot that they might be inclined to accept it if a suitable means of manufacture could be found?

MR. ANDREWS: The last part of your question is the big problem—a suitable means of manufacture. The sporting arms and ammunition manufacturers are studying the results of our tests in mathematical models. We hope we can test iron shot of other sizes and gauges and perhaps from that determine what the iron shot performance would be in other than the No. 4 load that we tested.

INSTINCTS, LAWS, AND DUCKS

ROLAND C. CLEMENT
National Audubon Society, New York City, New York

We often hear it said that hunting is an instinct. Until quite recently this view was almost confined to the cracker-barrel school of philosophy that has articulated most of the sportsman's beliefs about himself. That hunting is an instinct was of course said by those who wished to justify it as an irresistible urge of man that it is unwise, perhaps even dangerous to block, because such interference with a man's instincts might lead him to vent his pent-up excitation in some less acceptable way.

I raised this question at the waterfowl regulation hearings in Washington last August, suggesting that wildlife managers need to know much more about the sociology of hunting, since hunting regulations should not be mere abstractions from population biology. If the supply of game does not warrant a decent bag, I said, it might be better to close the season than reduce the bag to one or two birds since low bags may be unrealistic in expecting the hunter to control his instincts once afield. I was of course soon quoted in newspapers around the country, this time without qualifying question marks.

Unfortunately, no one has yet studied hunting from the viewpoints of psychology or ethology, and we have, so far, only a few crude analyses of the attitudes and make-up of the hunter population, such as the Ohio crosssectional study (Peterle, 1961). Most comments on hunting made by otherwise qualified observers have been casual ones, speculative, or made to bolster another point of view. In Robert Ardrey's overdramatic books (Ardrey, 1961), for example, it is the concept of territoriality that is being buttressed when he quotes anthropologists Washburn and Avis to the effect that "Unless careful training has hidden the natural drives, men enjoy the chase and the kill," and that, as an important activity during millennia of human evolution, hunting "had three important effects on human behavior and human nature: psychological, social, and territorial."

We may accept the fact that the enjoyment of "the chase and the kill" became part of man's psychological nature as the result of millennia of predatory behavior. A recent symposium volume, ***Man the Hunter*** (Lee *et al.,* 1968) summarizes the anthropologist's views most helpfully, without, however, adding anything new to our understanding of the "instinctual" nature of hunting. Whatever was built into human nature by our long history as hunters, this was of course done by a process of natural selection, favoring those physical and psychological characteristics that, in combination, made for a more successful hunter; and it was selected "for" because it had survival value under the conditions of life all those days till our. Cultural patterns reinforced the hunter's ways by rewarding them. The man who brings home the bacon is honored not only for his bacon but because he has the ability to bring it home!

This historical approach—the "how come?" attitude rather than the asking of an oversimplistic "why?"—will help us avoid considering instincts as "given" or preternatural factors, as though instinct were spelled, always, with a capital I. If we use this overladen term at all, we must use it to suggest that we are dealing with more or less stereotyped but complex behavior patterns composed of, or built on simpler drives. These simpler drives may be studied separately, but the behavior pattern, as a system, also requires study.

One such "basic drive" is that of aggression, perhaps essentially a spacing device present in many organisms and used both offensively (*i.e.*, in courtship) and in defense of territory. The Austrian ethologist Konrad Lorenz (1966) feels that man's aggressiveness is a built-in animal characteristic, likely to explode if too-long repressed, and thus in need of redirection or sublimation. The human implications of Lorenz' approach are spelled out in ***On Aggression***, much the best-known thesis, both because Lorenz writes well and because his theme was expanded upon by Ardrey in two readable but controversial books. Following Lorenz, Anthony Storr (1968), in ***Human Aggression,*** writes that ". . . aggressiveness is a problem to modern man (because) the natural exploratory urge to grasp and master the environment has perforce to be limited in a way which is bound to cause frustration. There are so many things which children must not do or must not touch; so that within all of us who have been brought up in western civilization, especially in urban civilization, there must be reserves of repressed, and therefore dangerous, aggression which originate from the restrictions of early childhood."

Before considering the implications of these psychological concepts, however, we must consider an opposite point of view.

A number of American behavioristic psychologists deny the existence of innate, or spontaneous aggression resulting from an accumulation of excitation—an internal force whose discharge threshold becomes lower and lower until released by some external stimulus, or "releaser," or until it explodes from internal pressure. Leonard Berkowitz (1968) of the University of Wisconsin is among the most active exponents of the contrary view that aggression is not endogenous but is a result of frustration. These proponents of the frustration-aggression hypothesis argue that whatever is innate about aggression is more analogous to a "wiring diagram" which may facilitate certain behavioral response sequences, but only in response to stimuli. It is, in short, a pathway rather than a force that goads to action.

These opposite views of aggression—one seeing it as the source of all progress and merely in need of constructive outlets, the other as a social maladjustment at the root of violence—might seem best left to the world of academic debate until they are resolved or compromised, but they are pertinent to our discussion because their implications lead to quite different social strategems. If Lorenz and his school are right, hunting may be a valuable release from the frustrations imposed by civilization; *i.e.*, hunting will help redirect innate aggressiveness, an aggressiveness which is otherwise a source of useful motivation so long as it is periodically released. On the other hand, if Berkowitz and his colleagues are correct, the catharsis concept of Lorenz is at best futile since, in their view, the control of aggression is environmental and cultural, and attempts at catharsis may actually aggravate circumstances. Ardrey, in *The Territorial Imperative*, took a very dim view of this alternative explanation and did not fairly present the case.

For example both observation and laboratory experiments by psychologists suggest that aggressive activity may induce further aggression. This is contrary to the catharsis theory. In humans, for example, venting one's spleen against a scapegoat seems actually to reinforce and maintain prejudice. In our eagerness to emphasize the good turn, we have forgotten that one insult also deserves another. The barrage of shots at a passing water bird which is triggered by some too-eager gunner when hunters are too closely spaced is an analogous illustration.

Incidentally, frustration is not mere deprivation, but rather, results from the failure to satisfy one's anticipations once these have been aroused. Psychologists call these anticipatory goal-responses. When everyone is poor, there is misery but no frustration in poverty; but when, as in our day, there is a "revolution of rising expectations" but the real accomplishments lag behind expectations, then there is deep frustration which may easily result in aggressiveness.

One of the most interesting, and important, discoveries of recent experimentation by American psychologists is the fact that the gun is itself a stimulus to aggression. Berkowitz (1968) has demonstrated that the mere sight of a gun leads to stronger attacks against a tormentor in experiments which allow college students angered by the test administrator to give him an electric shock of varying duration. It has also been suggested that aggressive toys (guns and other military appurtenances) stimulate aggressiveness in children. Further, the observation of aggression often stimulates aggressive behavior in the beholder, perhaps only by removing inhibitions (Mallick, 1966).

Socially, this evidence from psychology argues for a measure of gun control, and it has several important implications for wildlife management policy.

It is first necessary, it seems to me, to recognize that Americans have made a mania of guns. The use of guns to settle any or all disputes has long been ritualized by the western movie—an American rite if there ever was one—and this has of course been continued and made more pervasive by television. Many westerners will still tell you that they "feel naked" if they go afield without a sidearm. This historical cultural conditioning, whatever behavior it may predispose us to, certainly complicates the task of inducing the responsible use of guns by regulation of hunting seasons and bag limits. We have allowed commercial interests to greatly oversell the recreational aspects of the hunt, and both state and federal wildlife agencies have played into the hands of commercial interests by reinforcing these claims. The result is, on one hand, an excessive stimulation of a lust for hunting and the cruel setting up of unrealizable expectations; and on the other hand, the luring afield of so many nimrods that they get in each other's way, deplete the game supply, and compound one another's frustrations and the problems of democracy by shooting up the landscape.

My intuitive interest in the relation between open seasons and bag limits seems to be confirmed by our present partial understanding of the hunter's motivations. It turns out that whether or not hunting is an instinct, hunters should not be expected to behave ethically if they are encouraged to seek satisfaction afield and are then frustrated by circumstances the law-maker knew all too well could not lead to satisfaction. One mallard or one canvasback in the bag is ridiculous in terms of human behavior under present conditions. This means that the federal wildlife agencies should get out of the business of promoting hunting and stick to environmental conservation, population dynamics, and human behavior as it affects both of these. The States and private enterprise already do too much promotion.

We need to develop deeper insights in order to understand what men will, must, or ought to do.

I have merely opened a neglected area of social investigation in American wildlife conservation and make no pretense to originality or conclusiveness. Nevertheless, I would close this discussion by suggesting that—contrary to the assumptions of too many in the last generation—hunting cannot be democratized, *i. e.*, made available to the masses, because it requires a long apprenticeship and unhurried and uncrowded circumstances if it is to be pursued skillfully and ethically. This means, incidentally, that opening day should begin at noon everywhere to moderate the manic, frustrating and destructive opening-day fever.

The really expert waterfowlers and birdwatchers of the last generation were apprenticed to market gunners who could identify waterfowl as soon as they appeared on the horizon. Both Ludlow Griscom and Charles Urner, who taught my generation to identify ducks in the New York City region, attested to this. Today's unending stream of city-raised nimrods who are lured outdoors for the dollars they cause to flow through other people's hands don't have a chance to learn the fundamentals.

Aldo Leopold (1949) saw that hunting in our day is a drama, an exercise in reliving the past. He gave it a "split rail" or "Daniel Boone" function. Today we know that it reaches much farther back into the past—at least a million years—and that for 90 percent of our history we have been hunters. Done with full awareness, hunting can be a form of piety. We perhaps need to preserve it for those few who have a strong longing to relive these aspects of man's long history. Commercialism destroys this sensitivity, and now that cooperative coexistence has become more vital to our crowded way of life than aggressive territorialism, it will destroy hunting itself if the majority becomes impatient of the irrational behavior that commercialized gun-toting encourages.

LITERATURE CITED

Ardrey, Robert
1961. The territorial imperative. Artheneum, N.Y.

Berkowitz, Leonard
1968. The study of urban violence: some implications of laboratory studies of frustration and aggression. Amer. Behavioral Scientist. Mar.-Apr., pp. 14-17.

———. Impulse, aggression and the gun. Psychology Today. Sept., pp. 19-22.

Lee, Richard B. and Irven DeVore, ed.
1968. Man the hunter. Aldine Publ. Co., Chicago.

Leopold, Aldo
1949. A Sand County almanac, Oxford Univ. Press, N. Y.

Lorenz, Konrad.
1966. On aggression. Harcourt, Brace Co., N.Y.

Mallick, S. K., and B. R. McCandless.
1966. A study of catharsis of aggression. Jour. Pers. Soc. Psychology, 4: pp. 591-596.

Peterle, Tony J.
1961. The hunter—who is he? Trans. No. Amer. Wildlife Conf. 26:254-266.

Storr, Anthony
1968. Human aggression. Atheneum, N.Y.

DISCUSSION

MR. RETTINGER: This has given some of us a mental shock, I am sure. I believe these remarks stimulated some questions in your minds.

MR. DALE WHITSELL (Ducks Unlimited, Chicago): First of all I want to commend him for his presentation. There are several important aspects of his contribution that not only I but many others definitely agree with. I would like your opinion as to whether you feel there is continuity here with regard to what you have discovered in your readings and presentation. The statement is this:

"In law, ducks are game birds. As such they are preserved for sport and food. The economic value to the Nation is high. It includes, beside employment the whole train of industrial activities included, such as their unmeasurable value for recreation. The interest and unceasing work of sportsmen have been the forces which have so acted on public opinion as to bring about laws and methods to preserve the ducks. Nobody familiar with the history of game conservation could deny this fact. A proportion of the people want wildfowl preserved not for sport or food but because of the enjoyment of wildlife and beautiful nature, a feeling shared also by sportsmen. It is clear, however, that preserved up to their maximum numbers ducks will always provide a field of opportunity for nature lovers as great as for sportsmen."

Would you agree, sir, there is continuity between this statement and what you have said?

MR. CLEMENT: In general, I think there is continuity there. I do question, however, that our laws are giving adequate protection right now because I feel they have overlooked some sociological aspects of hunting. I had meant, just to put you into a more receptive frame of mind, to point out at the very beginning that obviously I am not anti-hunting. As a matter of fact, I think if you will study the paper you may come to the conclusion that I have given a strong pitch here for the preservation of hunting for sport. However, I am concerned about commercial pollution, if you will, of the whole thing.

MR. WHITSELL: I am very pleased to hear that and, as I indicated earlier, we definitely agree with some of your conclusions. I was glad to hear there was continuity, because what I read to you was from a record of the National Audubon Society under date of 1926.

MR. HENRY G. RIPPE (New York State Sportsmen's Council): I am glad to take note you were not opposed to hunting, but you stated that most contemporary hunters do not devote enough time to study to become good hunters. Am I to understand you mean hunting should be for a limited few and not for the masses?

MR. CLEMENT: You are putting this in a difficult sociological context, but I think if you face the facts, this is the way it comes out. I had not expected to run up against this problem but, certainly, with the growth of population, it will become impossible to provide equal hunting opportunities. As a matter of fact, the purpose of my paper is to prod the Fish and Wildlife Service into getting out of the business of promoting hunting for every Tom, Dick and Harry because they will end up by pushing the supply out of existence.

MR. RIPPE: I disagree with that. I think there is room for everybody interested in hunting in this country, and we should all move toward strong conservation efforts to prevent extermination of wildlife, particularly waterfowl, through the elimination of our wetlands, which are taking place right now. I say that we should not eliminate the hunter.

MR. CLEMENT: I agree that this is a controversial issue, as to whether or not hunting can be maintained for a majority, let's say. However, it is something we need to continue studying. Obviously, we must also get together and change the circumstances that are pushing the supply out of existence at the present time. Hunting is only one factor. Obviously loss of habitat is even more important, and so is environmental pollution by long-lived pesticides.

One of the frustrations of a meeting like this is that too many people take the given situation as unalterable. I do not buy this. It is up to us to make up our minds what we want and do something about changing the circumstances, particularly the economic circumstances that underlie so many of our problems. Possibly we do have different points of view, but I think our objectives are pretty much the same. We want to preserve these supplies so that as many people as possible may enjoy them, and the hunters certainly have an important stake in this.

MR. CLYDE PATTON (North Carolina): For many years we have put emphasis on the matter of using our game birds and animals and other wildlife as items of sport rather than items of commerce. We have had no hesitancy in promoting that idea in every possible way. You are exactly right in stating that our wildlife should be maintained, not only for hunting but also for photography, for watching and all of the other sporting uses.

How can we put more emphasis on that to accomplish what you are advocating?

MR. CLEMENT: How to get together and do it, from my point of view, is mostly a matter of undermining the false assumptions that underlie so many of our attitudes. This is my objective here this morning—just to prod you to think more deeply about it. We all have a responsibility to shoulder here.

MR. DON IRWIN (Virginia): You mentioned altering sites and circumstances. I am wondering about the field of education. In the United States there are 10 million golfers, and the support of golf is normally a part of physical education programs for teachers and students. Yet in the United States, on the other hand, there are over 13 million hunters and I seriously doubt that hunter safety and gun safety and the sport of hunting is taught in a physical education program. Would you care to comment on the situation and the possible implications?

MR. CLEMENT: Well, you are asking essentially how we can train the hunter. Well, this is a big job. It is going to have to be approached from many points of view but more fundamentally I feel, as I have said, we are inducing too many people to hunt. They get in one another's way and there is too much competition, too much frustration under present circumstances, and this, in turn, causes people to be hurried and therefore induces unethical behavior.

The ideal way to learn to hunt is to apprentice yourself to somebody who knows the business from long tradition and to be disciplined along the way and not to be pushed into a situation that will make you look foolish.

Much of public hunting in our day is altogether too crowded, too hurried and therefore involves an impossible set of circumstances for ethical performance.

STATE PROBLEMS IN THE MULTI-PURPOSE WATER ACT

RUSSELL W. STUART
North Dakota Game and Fish Department, Bismarck, North Dakota

This presentation deals with the problems that states are having and will be experiencing with the implementation of Public Law 89-72 in large federally-sponsored water projects.

Before getting into a discussion of the Federal Water Project Recreation Act, it is necessary to review briefly the Fish and Wildlife Coordination Act because of the inter-relationship of these two federal laws.

For many years, state game and fish agencies have expressed concern over the fish and wildlife losses that occur with the construction of federal water projects. Congress recognized this problem several decades ago, and attempted to correct it by an Act passed in 1934 to provide for mitigation of fish and wildlife losses caused by a federal water project. This Act was amended in 1946 and again in 1958 when it acquired the title of the Fish and Wildlife Coordination Act.

This Coordination Act permitted the state game and fish agency to have a part in the overall planning of a Federal water project, and to make suggestions that would mitigate the fish and wildlife losses caused by the project. There are many inherent weaknesses in the Act. Perhaps the greatest deficiency of the law is the fact that fish and wildlife mitigation is optional with the sponsor. The language is permissive rather than mandatory, so if a sponsor chooses to ignore fish and wildlife losses or gives token assistance to alleviate these losses, there is nothing that a state game and fish agency can do about it.

Another problem with the Act is in the use of the word "mitigate" in reference to project-caused fish and wildife losses. Mitigation, by definition, means to "make less severe." Thus, if provisions were made by the project sponsor to reduce the fish and wildlife losses by one percent they would, in turth, be "mitigating" losses. I think it is safe to assume that the wildlife losses caused by all Bureau of Reclamation and Corps of Engineers projects in the past twenty-five years have been mitigated to a very small extent. Fisheries have not suffered as severely, but quantity has been substituted for quality because the change has been from a stream fishery to a reservoir fishery. As one state director put it . . . "How do you substitute crappies and bluegills for trout?"

Many Congressional leaders have, for some time, recognized the need for providing fish and wildlife and recreational enhancement in federally-sponsored water projects. Very likely, the fact that project sponsors began incorporating fish and wildlife and recreation enhancement features into projects to show a favorable cost-benefit ratio, prompted Congress to act. In July, 1965, Congress passed the Federal Water Project Recreation Act, which is now known as Public Law 89-72.

The Congressional policy statement concerning this Act declares that (1) full consideration shall be given to outdoor recreation and fish and wildlife enhancement in federal water resource projects; (2) the sponsoring agency shall take into account existing and planned public recreational areas; and (3) project planning agencies shall encourage non-federal public bodies to administer project lands and waters for recreation and fish and wildlife enhancement.

The Act further provides that non-federal governmental entities must reimburse the Federal Government for at least one-half of the costs of project features added specifically for recreation and fish and wildlife enhancement. Provision is made for a repayment period of fifty years, with an interest rate of three and one-eighth percent charged on the unpaid balance. Further, the state agency is allowed to charge user fees to the project lands and use this revenue to retire the separable costs.

All annual operation and maintenance costs of fish and wildlife and recreation enhancement features must be borne by some non-federal governmental entity.

The Act is not applicable to the Soil Conservation Service's Small Watershed Act (Public Law 566) nor to T.V.A. Thus, this discussion will concern itself with those projects sponsored by the Corps of Engineers and the Bureau of Reclamation.

Although state agencies other than the departments of game and fish will be involved because the law includes provision for general outdoor recreation enhancement, an effort is made to confine the discussion to the effects of this Act on fish and wildlife resources and the financial problems created for the departments that manage these resources.

A questionnaire was sent to the game and fish directors of the 48 conterminous states, asking for answers to certain specific questions as well as general comments concerning their experience with Public Law 89-72 (Figure 1).

Of the 48 questionnaires mailed, 34 were returned before this report was prepared. The 14 states that failed to respond were primarily those in the eastern and southeastern part of the country. The states of Rhode Island, Delaware, South Carolina, Alabama, New Hampshire and Wisconsin indicated that they had no projects pending and as a result had given little or no thought to the Act and its impact on fish and wildlife. Deleting the reports from these six states leaves 28 reports that will be referred to in this discussion (Table 1).

A total of 187 projects were listed as either authorized or pending, with the number per state varying from one to 25. Inasmuch as most of the projects have not been authorized, many of the states were not able to give estimates of the reimbursable, or state's, share of the cost of fish and wildlife enhancement.

However, Table 1 indicates that the average state's share of separable costs is extremely large and represents an additional financial burden that most state agencies are unable or unwilling to assume.

One important item that is now shown by the table is the annual operation and maintenance costs that the state agency must provide. Few projects have progressed to the point where these costs have been made available. Once these become known it is very possible that they will create an even greater financial burden than the original separable cost of the facilities.

It is interesting to note that only two states indicated that they thought they were getting 100 percent mitigation on federal water projects. Twenty-four states, or approximately 90 percent of those reporting, indicated that they were not obtaining complete mitigation of losses caused by projects. Many indicated that mitigation measures

(sample of questionnaire mailed to game and fish directors of the 48 conterminous states:)

North Dakota Game and Fish Department
Bismarck, North Dakota 58501

Questionnaire regarding)
Public Law 89-72 and its)
financial impact on state)
game and fish agencies.)

STATE:____________________

1. List the number of authorized and pending federal water projects in your state wherein Public Law 89-72 is applicable.

a. ____________________ d. ____________________

b. ____________________ e. ____________________

c. ____________________ f. ____________________

2. How much money is your department expected to pay in separable costs on the above projects?

a. ____________________ d. ____________________

b. ____________________ e. ____________________

c. ____________________ f. ____________________

3. In your estimation, are you obtaining complete mitigation of wildlife and/or fish losses due to a project?

Yes________ No____________

4. If the answer to number 3 is No, what is your attitude concerning payment of fifty per cent of the cost of wildlife enhancement features?

5. Have you entered into any agreements with the sponsors for repayment of 50 per cent of separable costs on any project?

Yes________ No____________

6. General comments on P. L. 89-72?

(Buy North Dakota Products)

State	No. of Projects Authorized or Pending	State's Share of Separable Costs	100% Mitigation? Yes	100% Mitigation? No	Agreements Signed? Yes	Agreements Signed? No
Alabama	(no projects)	$ ---	---		---	
Arizona	23	333,000		x		x
California	6	615,000		x		x
Colorado	20	16,557,600		x		x
Delaware	(no projects)	---	---		---	
Idaho	7	1,746,500		x		x
Indiana	7	14,356,000		x		x
Iowa	2	2,160,500		x		x
Kansas	25	unknown		x		x
Kentucky	6	800,00		x		x
Louisiana	2	unknown		x		x
Michigan	9	unknown		x		x
Minnesota	1	60,000	x			x
Mississippi	unknown	unknown		x		x
Missouri	15	14,469,000		x		x
Montana	5	532,500		x	x	
Nebraska	20	5,000,000		x	x	
New Hampshire	(no projects)	---	---		---	
New Mexico	1	unknown	x			x
North Dakota	2	860,000		x		x
Ohio	3	unknown		x		x
Oklahoma	10	unknown		x		x
Oregon	7	1,239,500		x		x
Pennsylvania	(no projects	---	---		---	
Rhode Island	(no projects)	---	---		---	
South Carolina	(no projects)	---	---		---	
South Dakota	2	969,000		x	x	
Tennesee	(no projects)	---	---		---	
Texas	unknown	unknown		x		x
Utah	3	unknown		x		x
Vermont	6	unknown		x		x
Virginia	3	300,000		x		x
Wisconsin	(no projects)	---	---		---	
Wyoming	2	302,000		x		x

reduced the losses by a very small percentage. Several made note of the fact that in many projects little or no attempt was made to alleviate fish and wildlife losses. This was especially true of projects constructed in the 1940's and '50's.

The most significant information from the questionnaire was gleaned from comments expressed by the several states. Although there was considerable variation, there were several criticisms of the Act upon which there was almost universal agreement.

Practically every state expressed concern that its department would not be able to assume the financial burden of paying 50 percent of the costs of the enhancement features. Since most state game and fish agencies must rely on license monies for most of their income, other departmental programs will suffer. Many of the states felt that it would be prudent to by-pass enhancement features of a federal water project and use their federal matching monies (Pittman-Robertson and Dingell-Johnson) to acquire land and construct their own reservoirs. Game and fish federal matching is on a 75 percent federal and 25 percent state basis, so it is good business to initiate their own projects.

Many states were even more concerned with the annual operation and maintenance costs involved. Since these are not considered separable costs, the entire amount would have to be paid by the department. As an example, the state's separable costs on 20 projects in Colorado are estimated at approximately 16.5 million dollars. It is also estimated that the annual operation and maintenance costs will amount to 1.9 million dollars for these projects. Inasmuch as the separable costs may be repaid over a fifty-year period at three and one-eighth percent interest, the annual cost of interest and principle approximates $825,000 . . . . or slightly over 40 percent of the annual operation and maintenance costs.

It was generally agreed that any water impoundment program is detrimental to upland game, big game and furbearers, and that it is virtually impossible to replace the losses on lands acquired by the project sponsor. For example, a reservoir that covers five thousand acres actually and permanently destroys that many acres of game habitat. Even with the best wildlife management practices on adjacent project lands, the loss cannot be mitigated to any great degree.

Perhaps the greatest inequity in the Act is the fact that wildlife losses are not balanced against the so-called enhancement features before the state's separable costs are calculated. For example, if in a water storage project it is determined that the annual wildlife losses amount to $15,000 and the mitigation features reduce this to $10,000, and on the other hand it is determined that the fisheries will be enhanced by $20,000 annually, it would seem fair that the net annual benefits would amount to $10,000. However, this is not the way it works. The federal sponsor ignores the losses and at the same time requires the state agency to pick up half of the separable costs for enhancement features.

It should also be taken into consideration that state fish and game agencies have taken very substantial losses in federal water projects over the past three or four decades, with little or no attempt made to mitigate these losses. Thus, the states feel that they have an accumulation of rather large credits against the Corps of Engineers and the Bureau of Reclamation, and that there should be a balancing of accounts before the agency is required to start paying a share of separable costs. In my own state of North Dakota, two dams on the mainstem of the Missouri River have reduced our white-tailed deer production and potential harvest by about 15 to 20 percent. This is not only a loss to our big-game hunters but also has resulted in a financial loss to the Department through reduction in license sales. Also, neither the hunters nor the Department were willing to trade deer and upland game hunting for some mediocre reservoir fishing.

Briefly, other comments were: "Mitigation in kind is seldom accomplished." "State agencies are not given any funds for personnel and expenses in making studies to determine the impact of a project on fish and wildlife resources." "Enhancement features are not necessarily the state agency's choice." "Certain outdoor recreationists are getting a free ride on P.L. 89-72 projects at the expense of the hunting and fishing license buyer. Pleasure boaters and water skiers are examples." "The Corps of Engineers is more difficult with which to deal, and more arbitrary, than is the Bureau of Reclamation." "Flood control ordinarily benefits a few local areas, and navigation almost always provides personal or corporate gain, while fish and wildlife is of benefit to all our people."

Recommended solutions to the problem:

1. An in-depth study of all the cost-sharing criteria of a multipurpose federal water project.
2. A more realistic measure of fish and wildlife values. (Should a man-day of bluegill fishing be given the same value as a man-day of quality big game hunting?)
3. State fish and game agencies should be given veto power over certain federal water projects. Certain projects should not be constructed because of adverse ecological effects.
4. One-hundred percent mitigation of fish and wildlife losses should be provided before consideration is given to separable cost enhancement features.
5. The federal sponsor should share at least 50 percent of the

operation and maintenance costs of fish and wildlife and recreational enhancement features.

DISCUSSION

MR. RETTINGER: Thank you, Russ, for a good summary on this important problem. I know, gentlemen, that this involves a vital concern to many of you throughout the nation.

MR. JAMES McBROOM (Washington, D. C.): I don't want to argue with Mr. Stuart, but I would like to present a little perspective on some of the matters he discussed.

He began his paper by pointing out the weaknesses of the Fish and Wildlife Coordination Act. No one would say that this Act is perfect, but I don't think it needs to be run down in this fashion without taking a look at the other side.

Mr. Stuart comes from North Dakota, and one of the biggest and best projects for fish and wildlife that has ever been authorized is in the State of North Dakota. This was worked out under the Coordination Act. It is the Garrison Diversion Unit of the Missouri River Basin Project of the Bureau of Reclamation. This is an irrigation project for 250,000 acres of land. Now, mind you, with that acreage of irrigated land, authorization for this project also included acquisition and development of 147,000 acres of waterfowl area. This acquisition will be done by the Bureau of Reclamation with project funds not costing the duck stamp fund or the North Dakota Fish and Game Department one dime. Out of the total 147,000 acres, I believe that around 25,000 of them will be turned over to the North Dakota Fish and Game Department without cost—a free gift. Further, it is true that a lot of the 147,000 acres of land will be for mitigation purposes, but, beyond mitigation, there is a very large enhancement bonus for the waterfowl resource of North Dakota. North Dakota being what it is in the duck business, this will benefit people all over the country.

This was accomplished through the Fish and Wildlife Coordination Act and the good work of Russ Stuart and his group working with the Fish and Wildlife Service. That is a pretty good dividend, I would say. Again, the water project Recreation Act is not perfect. But there was a lot of consideration of it by Congress. However, they passed it in their wisdom.

Secondly, through this Act, the Fish and Game Department can take its choice of the enhancement facilities on which it wants to participate. I would argue with Russ on that point.

Thirdly, the Fish and Game Department can get enhancement for some of these for half price, with 40 years to pay. I think operations and maintenance are something else that need to be looked into.

One more point. Russ suggests a veto of water resources projects by the Fish and Game Department. I would suggest that there is a veto which the Fish and Game Department can exercise. If they are strong enough to get their state governor to oppose the project, then that is their veto.

MR. STUART: Jim, I would like to rebut just a little.

You are correct in your reference to enhancement for waterfowl in the Garrison Division project. However, I must point out that the State of North Dakota was charged with about $680,000 of separable costs attributed to enhancement of fish and resident wildlife. Upon learning this, I informed the Bureau of Sport Fisheries and Wildlife that the North Dakota Game and Fish Department was not going to assume this obligation. The obligation was eventually assumed by the Garrison Diversion Conservancy Board.

On the proposed Kindred Dam project on the Sheyenne River, North Dakota, the Game and Fish Department has been opposing the project since its inception because of its adverse effects on wildlife and timber resources. In spite of this, the final report came back from the Corps of Engineers showing substantial fish and wildlife enhancement and placing the State's share of separable costs at approximately $190,000.

TECHNICAL SESSION

Wednesday Morning—March 5

Chairman: WALLACE G. MACGREGOR
Game Management Supervisor, California Department of Fish and Game, Sacramento

Discussion Leader: JOHN BYELICH
Habitat Biologist, Michigan Department of Conservation, Lansing

---

FOREST AND RANGE RESOURCES

HOME-RANGE AND ACTIVITY STUDIES OF IMPALA IN NORTHERN KENYA

ERNEST D. AND JUANITA ABLES[1]
Department of Wildlife Ecology, University of Wisconsin, Madison

The objectives of this study were twofold: (1) to determine home-range size and use, daily activity patterns, and habitat selection of impala (*Aepyceros melampus*), and (2) to demonstrate the applicability of radio-tracking in monitoring activities of free-ranging animals in East Africa.

Impala are among the most numerous and widespread antelope in East Africa (Simon, 1962 and Astley Maberly, 1960), in Rhodesia (Dasmann and Mossman, 1962), and in parts of South Africa (Brynard and Pienaar, 1960). The natural habitat of the impala is similar to that of the white-tailed deer (*Odocoileus virginianus*) in that impala seem to avoid open plains and dense forests. Their preference for "bushed savanna" and forest edge was mentioned by Darling (1960) and further documented by studies of Dasmann and Mossman (1962) and Lamprey (1963). The only intensive study of impala in East Africa was concerned with behavior (Schenkel, 1966).

DESCRIPTION OF STUDY AREA

The 2.5 by 5-mile study area (Fig. 1) was located at Maralal (1° 05′ N. latitude and 36° 41′ E. longitude), 168 air-miles north of

[1]Present address: Caesar Kleberg Research Program in Wildlife Ecology, Texas A&M University, College Station, Texas 77843.

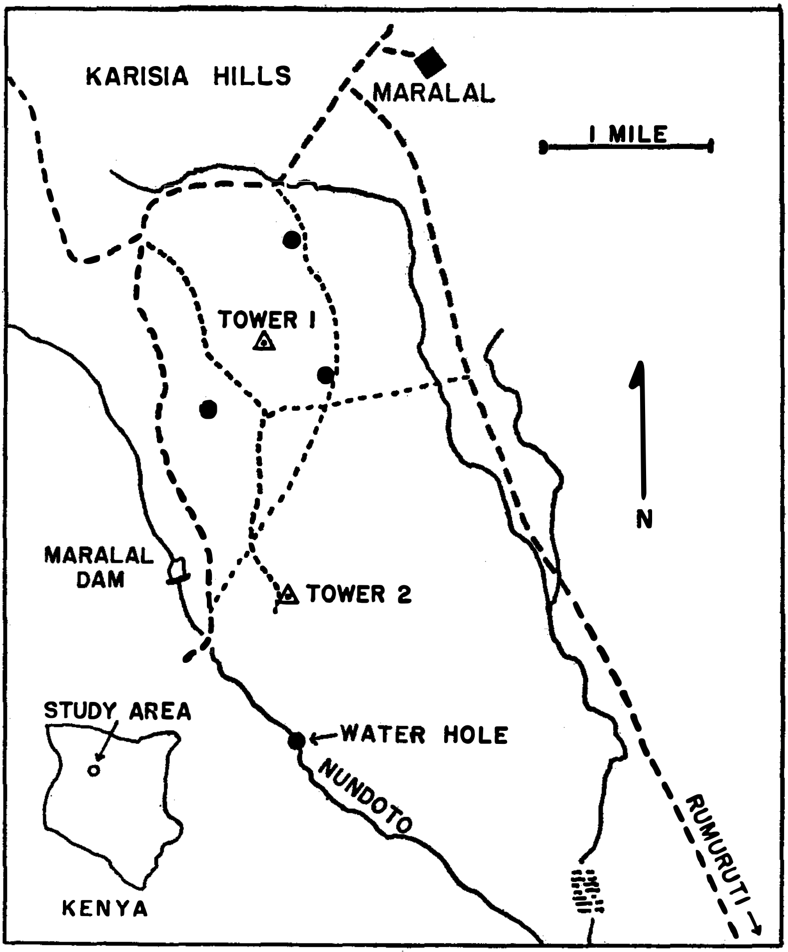


Figure 1.—Study area in Northern Kenya.

Nairobi in the Northern Frontier District of Kenya. The climate generally is semi-arid and is classified ecologically as of marginal agricultural potential with a natural vegetation of *Acacia* bushland interspersed with grassland (Pratt, Greenway, and Gwynne, 1966). Local ranges of hills were important in modifying the climate. On the extreme north portion of the study area on the slopes of the Karisia Hills a 30-inch annual rainfall supported cedar (*Juniperus procera*) forests. Less than five miles southward a 20-inch annual rainfall supported dry *Acacia* bushland. Heavy, general rains occurred in August, 1966, very light and local rains in November, and light but general rains during April-May, 1967.

Soils were red to strong-brown friable clays with a laterite horizon. Subsoils often contained iron concentrations. Soils in this region were derived from rocks of volcanic origin (Atlas of Kenya, 1959). The terrain was rolling to steep with a maximum elevation of 6,800 feet near Tower 1 (Fig. 1) and a minimum of 6,000 feet at the south end of the study area. A seasonally flowing stream, the Nundoto, formed the eastern and southern boundary. Temperatures seldom exceeded 80-85°F during the day, and attained lows of 40-50°F at night.

LAND USE AND ANIMAL POPULATIONS

Domestic livestock are one of the most important biotic influences in this region, often severely overgrazing the range. Of more than 20 species of grasses collected in the vicinity of Maralal, nearly all were considered unpalatable for cattle (Ian Hughes, personal communication). Livestock numbers on the study area varied from 386 resident cattle to 2,000+ head for periods of 2 to 3 weeks during cattle auctions. In addition there was a resident population of 60 goats, 23 donkeys, and 3 camels.

Wild animal numbers varied according to the season with the larger populations present during the general rains in April. Fourteen species of wild herbivores totaling from 978 to 1418 animals were recorded during four ground counts. Impala were most numerous (469 to 624) with Burchell's zebra (*Equus burchelli*) (243 to 380) and Thompson's gazelle (*Gazella thomsonii*) (178 to 206) next in abundance. The combined numbers of both domestic and wild herbivores totaled approximately 1500 animals, or 120 per square mile during the dry season. This figure does not include transient herds of cattle, elephant (*Loxodonta africana*), buffalo (*Syncerus caffer*), and eland (*Taurotragus oryx pattersonianus*).

In contrast to potential prey, numbers of large predators were low. Local herdsmen readily reported the presence of lions (*Panthera leo*), leopards (*P. pardus*), and cheetah (*Acinonyx jubatus*). Two lions were irregular visitors, two leopards were more or less resident, and a cheetah was seen on one occasion. Spotted hyena (*Crocuta crocuta*), were judged numerous; black-backed jackals (*Canis mesomelas*) and one family group of bat-eared foxes (*Otocyon megalotis*) were resident.

The study area was within a local game sanctuary, and legal hunting was not an important influence on resident animals. However, poaching sometimes occurred. Free-ranging domestic dogs were one of the greatest disturbing influences on local game animals, especially during the season of parturition.

MATERIALS AND METHODS

Radio-tracking Equipment:

The circuitry of the radio transmitters was the same as described by Cochran and Hagen (1963). Pulsed-signal transmitters of individual radio frequencies between 52 and 54 megacycles were assembled in the laboratory of the Kenya Game Department at Maralal. Construction and testing procedures were similar to those described by Verts (1963). Completed transmitters with two 1.4-volt Mallory ZM-12 mercury batteries were embedded as a unit in cold-curing dental acrylic. Weights of these units varied from 150 to 200 grams. The expected operating life was 150-300 days, depending on power requirements of each transmitter.

Transmitters were attached to the impala by means of a collar around the neck. These transmitter-collars, 20 inches in circumference for males and 16 inches for females, were made of 0.25 by 1.0-inch polyethylene strips. Two materials were used for the actual antenna loops, 0.5-inch wide strips of phosphor-bronze or 20-gauge insulated electrical wire. Bolting the ends of the collar together completed the electrical circuit and activated the transmitter. Impala were captured by drug-darting (Ables and Ables, in press).

Hallicrafter's WF-4000, fully transistorized, battery powered, short-wave receivers were equipped with Ameco frequency converters designed to receive the 52-54 megacycle band and convert down to 7-9 megacycles. Each radio signal was separated on the tunable dial by a 0.5-inch interval, thereby making easy the identification of individual signals.

The tracking system consisted of two tracking stations spaced 1.5 miles apart. Each station consisted of two vertically polarized yagi antenna spaced 16 feet apart on top of 30-foot rotatable towers. The towers were constructed of three 10-foot sections of 3-inch diameter water pipe. The guy wires were attached to ball-bearing joints, the tower base rested on a steel plate containing a ball bearing, and the entire tower was easily rotated by hand. A pointer-arm was attached near the tower base and radio-direction to the nearest 1 degree were read from a 24-inch diameter compass dial.

Accuracy of the system was assessed by placing a transmitter in each 20-degree arc around each tower and taking 10 radio bearings on each transmitter location. The mean error of the 360 bearings was 1.1 degrees with a range of 0-7 degrees.

Simultaneous bearings from each tower were taken at 15-minute intervals. Notations of activity were also recorded. Seventy-four percent of the fixes were taken from 6 p.m. to 6 a.m., and 26 percent from 6 a.m. to 6 p.m. Tracking periods were 12 hours in length at first but later reduced to 6 hours because of the too strenuous schedule for two persons.

Analysis of Data:

Aerial photographs were used to make a mosaic which was then enlarged to a scale of 8 inches per mile. Major vegetative types were outlined and checked for accuracy by a ground reconnaissance. Radio fixes were plotted on tracing-paper overlays by using a grid system graduated in 1-degree segments.

Home-range boundaries were drawn by using the minimum-area methed of Mohr (1947). Activity radii were calculated by first computing the geometric center of the fixes (Hayne, 1949) and then measuring the distances to each fix (Dice and Clark, 1953). All measurements of area were made with a compensating polar planimeter.

RESULTS AND DISCUSSION

Eleven impala were radio-tracked for 6 to 38 days each over periods ranging from 9 to 176 days. Thirteen transmitters were placed in operation, and eight were recovered prior to the termination date of 20 April, 1967. The major cause of transmitter failure was mechanical damage as a result of fighting between males. Adult male No. 6 was recaptured twice for replacement of his transmitter which had received broken antenna connections. Antennae constructed from 0.5-inch wide phosphor-bronze were not broken, but those made of 20-gauge electrical wire were easily severed by horns of fighting males. Only two of the recovered transmitters had ceased operating because of battery failure.

Daily Activity Patterns:

The impala were most active during the morning hours from 6 a.m. to 10 a.m., and during the afternoon and evening from 4 p.m. to 8 p.m. (Fig. 2). A lesser peak of activity occurred from 11 p.m. to 1 a.m. The pronounced higher level of activity of males from midnight to dawn was due primarily to herd males seldom resting.

The daily activity followed a routine of feeding during the early daylight hours, resting in cover during the hotter portion of the day, feeding again during the late afternoon, and resting at night in the open. Observations of the herds during the periods of restlessness at midnight revealed that most members of the herds were feeding. During periods of new vegetative growth following rains impala frequently spent most of the day feeding.

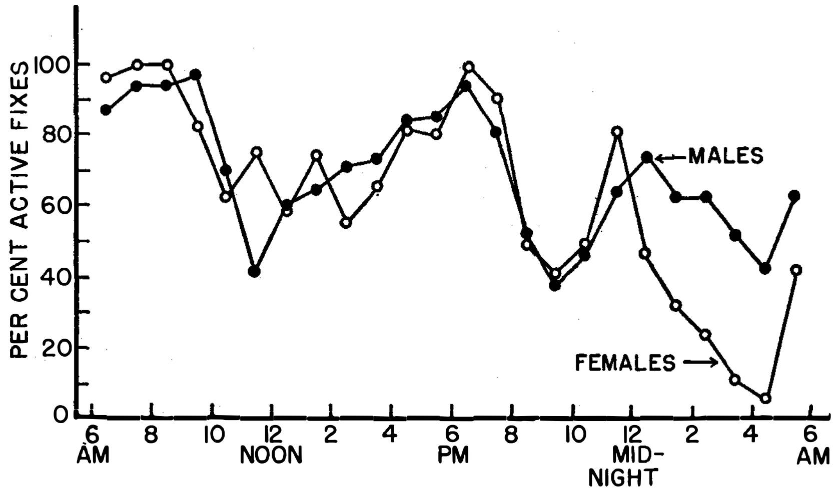


Figure 2.—Diel activity pattern of 8 male and 3 female impala.

The choices of daytime and nighttime resting sites were possibly due to anti-predator and comfort-behavior. Cover during the day offered protection from the sun and concealment. Open areas at night would seemingly make it more difficult for predators to approach without being detected.

Size of Home Ranges:

Some common parameters of home ranges (Table 1) show that impala were not highly mobile. Seven of the 11 animals had home ranges smaller than the 1.2-square mile average. There was no significant association of home-range size with time tracked. Adult male No. 1 was tracked for the longest period of time and had a home range smaller than average.

Expressing home range in terms of a mean activity radius is a

TABLE 1. SOME ESTIMATES OF HOME-RANGE PARAMETERS OF 111 IMPALA.s

Animal No.	Length (ft.)	Width (ft.)	L/W	Area (acres)	Activity Radiu
#1 Ad male	7,850	5,020	1.57	540	1400 ± 2160
#2 Ad male	11,290	10,890	1.04	1,805	2570 ± 3020
#3 Ad male	13,530	7,590	1.78	1,600	2960 ± 2380
#4 Ad male	6,700	2,700	2.43	280	1250 ± 1160
#5 Juv male	6,800	5,940	1.14	575	1860 ± 1900
#6 Ad male	7,000	6,200	1.13	710	2140 ± 1360
#7 Ad male	9,370	3,830	2.45	575	300 ± 2100
#8 Ad female	12,940	6,070	2.13	1,130	2550 ± 2250
#9 Ad female	7,790	2,900	2.68	310	1290 ± 1260
#10 Ad male	7,060	3,830	1.84	360	1820 ± 1850
#11 Ad female	7,790	4,500	1.71	565	1820 ± 1900
Average	8,920	5,420	1.65	770	2030 ± 1900

convenient method of showing mobility. The mean plus or minus 2 standard deviations will normally encompass 95 percent of the observations. The mean of the impala activity radii was 2030 ± 1900 feet, and suggests that 95 percent of the activity of the impala was confined to an area with a radius of approximately 0.73 mile.

Sizes of daily ranges were less than one-half those measured during the total tracking periods. Mean parameters of areas covered during sixteen 12-hour tracking periods were: length 4,490 feet; width 2,050 feet; and area 150 acres.

Linearity of the home ranges was associated with linear features of the habitat. In the case of impala No. 2, 5, and 6 which did not have linear ranges, internal patterns of use were strongly linear. The major habitat features which influenced impala movements were streams and vegetation along drainage systems associated with streams.

Habitat Use:

Vegetation—There were significant differences between the amounts of time spent by impala in the five habitat types and the amounts of time expected through random use (Table 2). Most of the value of Chi square in the day+night column was contributed by grassland and conifer forest; the former receiving greater use than expected and the latter less use than expected. Food habits and nighttime resting behavior were the reasons for the greater use of grasslands. Impala are apparently grazers by choice and browse woody vegetation during drought periods when availability of grasses and forbs is low. The conifer forests were densely undergrown and were avoided by impala. Differences in habitat use were more discernible when the numbers of fixes in each type during the day were contrasted with the number of fixes in the same type during the night. During the day only grassland received less use than expected, and the other four vegetative types, all used for cover by the impala, received greater use than expected. At night this situation was reversed. The largest Chi-square value was contributed by differences in day vs night use of

Vegetative type	Per cent in type	Total use (Day + night)			Day use (6 am-6 pm)		Night use (6 am-6 pm)		
		Ob.	Ex.[1]	Chi-sq.	Ob.	Ex.[2]	Ob.	Ex.[2]	Chi-sq.
Bush	45	1413	1489	3.88	455	367	958	1046	28.1**
Grassland	43	1596	1423	21.0	332	415	1264	1181	19.1**
Deciduous forest	5.8	160	192	6.4	107	42	53	118	177.5**
Open cedar forest	4.2	124	139	1.62	36	32	88	92	0.51
Cedar forest	2.0	15	66	37.9	13	4	3	12	24.1**
		Total Chi-square =		70.80**					

[1] Expected values based on per cent of area in type.
[2] Expected values based on 26 per cent of the fixes taken during the day and 74 per cent at night.
** Significant at 99 per cent level.

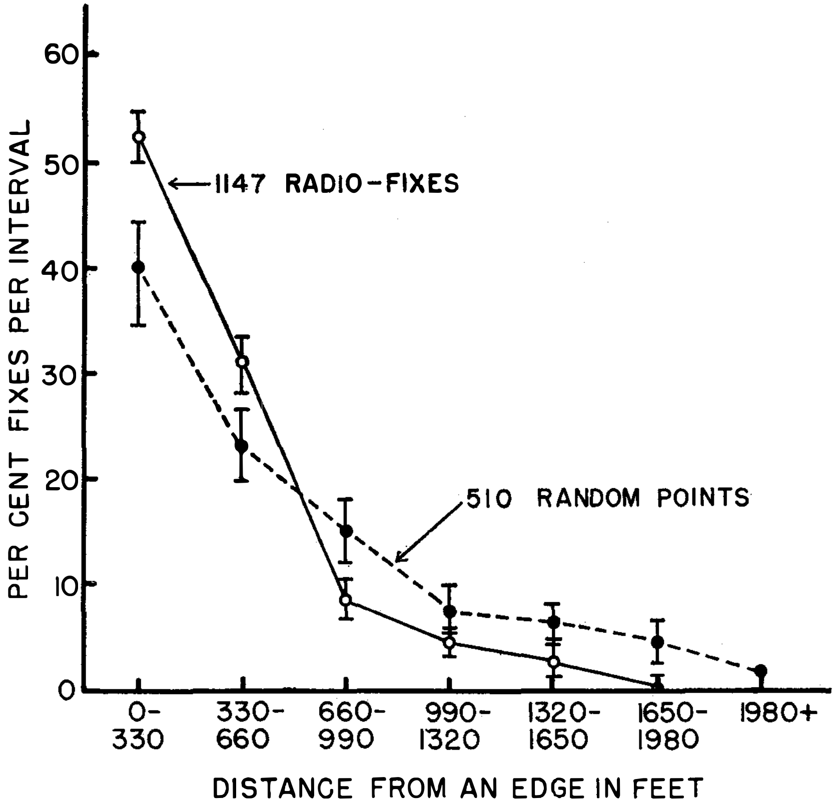


Figure 3.—The association of impala with an edge (95 percent confidence levels).

deciduous (*Acacia* spp.) forests. These forests were associated with the Nundoto stream and were generally avoided at night.

Edge Effects—Impala were associated with zones of transition between vegetative types (Fig. 3). In this analysis a population of random points was plotted on a map of the study area on which the five major vegetative types were delineated. The distance of each random point from an edge was measured and the results tabulated by 330-foot intervals. Approximately one-third of the radio fixes were treated in like manner. A comparison of the results shows a significantly larger percentage of the fixes in the first two 330-foot intervals, and significantly fewer fixes in the longer intervals than expected by chance. This association with edges could possibly have been stronger if the accuracy of the tracking system had permitted a more precise determination of the location of the animals. The vegetative type designated as bush contained many small openings in which we frequently observed impala. However, the inherent accuracy of the tracking system prevented pin-pointing an animal in small openings at distances of 1 to 3 miles.

Water—Home ranges of all impala contained sources of drinking water during the tracking periods. Nine of the 11 ranges contained permanent or semi-permanent water supplies. The ranges of males No. 4 and 10 did not have water during the dry season, but during the tracking periods of these two animals water was available from frequent rains.

Whether or not the impala drank water could not be determined by radio tracking. However, two major water sources were visible from the tracking stations. The herd to which female No. 9 belonged drank regularly during both morning and evening hours at a water hole southwest of Tower 1 (Fig. 1). When this water supply dried up the herd began watering at the Maralal water supply dam. The herd to which juvenile male No. 5 belonged also watered at this dam, but their schedule was irregular. The times at which other radio-tagged impala were near water supplies also varied, sometimes during the morning and sometimes during the afternoon. The importance of water to impala is best indicated by their more or less regular travel to water during the dry season and failure to travel to the usual water supplies during the rainy season.

Effects of Disturbances:

The impala reacted to lions and free-ranging domestic dogs by increased alertness. Two lions sometimes ranged along the Nundoto stream where they killed zebra and domestic cattle. During the periods when these lions were present the impala on the Nundoto, the two herds containing male No. 2 and female No. 8, became very wary and difficult to approach. The flight distance from a vehicle increased from the usual 20-30 yards up to 200-300 yards. There was no other detectable change in behavior, nor was there a shift in range.

The presence of free-ranging dogs was the greatest disturbing influence on impala. Persistent chasing by dogs resulted in extremely wary animals that were impossible to approach in a vehicle closer than 300-400 yards. During the period of parturition in April both bat-eared foxes and black-backed jackals followed the herds and attempted to catch the young. This harassment had only a mild influence on the flight distance, and the herds could still be approached sufficiently near for drug-darting.

The presence of large numbers of livestock plus the herdsmen, and perhaps more importantly the attendant dogs, caused the only major shifts in home ranges. On August 5, 1966, before radio-tracking began, 1500-2000 herd of cattle were held on the study area for three weeks. Impala plus most other game moved southward for distances of 3 to 6 miles. On 10 March, 1967 a herd of 200+ head of cattle was temporarily retained in the range of male No. 1, who subsequently moved 3 miles to the south. When the cattle departed one week later, male No. 1 returned to his usual range. Adult male No. 4 temporarily shifted approximately 1.5 miles, when a herd of cattle occupied his daytime resting site.

Social Behavior:

This study was not concerned primarily with behavior, but certain aspects of social behavior were important in influencing movements of the impala. The impala with the largest ranges, adult males No. 2 and 3, were continually changing in social status.

Male No. 2 was a herd male when captured and subsequently and alternately changed from a herd male to a lone bachelor or a member of a bachelor herd at least six times. Male No. 3 also alternated as a herd male and a bachelor.

Instability of the herds seemed characteristic of this population of impala. A total of 49 changes in herd associations of the 11 radio-tagged impala was observed. Herds frequently came together and split in an unpredictable manner. Juvenile male No. 5 sometimes went with the herd of female No. 8, at other times with female No. 9, and occasionally with a bachelor herd. On one occasion all three radio-tagged females were in a large group of 165 animals. Instability of herd structure probably is not as pronounced among less dense impala populations, but our scant observations point out the need for using marked individuals in studies of social behavior.

SUMMARY

Eleven impala, 8 males and 3 females, were radio-tracked in Northern Kenya during 1966-67. Peaks in daily activity occurred from 6 a.m. to 10 a.m. and from 4 p.m. to 8 p.m. The impala stayed in cover during the hotter hours of the day and rested in the open at night. Average size of home ranges was 1.2 square miles, and average size of 12-hour ranges was approximately 50 percent less. The impala avoided dense cedar forests at all times and spent significantly more time in open grasslands at night than during the day. There was a significant association of impala with vegetative edges. Impala herds traveled to water more or less regularly during the dry seasons. The greatest disturbing factor was the presence of lions, free-ranging

domestic dogs, and herds of cattle. Herd structure was instable and social behavior influenced the amount of movement by males.

ACKNOWLEDGMENTS

We are grateful to the Ministry of Tourism and Wildlife and Game Department of Kenya for assistance and provision of facilities during field investigations. Special thanks are due Mr. David W. J. Brown, formerly Chief Game Warden; Mr. Stan Bleazard, Assistant Chief Game Warden; Major R. T. Elliot, Divisional Game Warden, Maralal; Dr. D.R.M. Stewart of the Fauna Research Unit; and Dr. J. M. King of the Capture Unit. Dr. D. S. Kettle and Dr. J. B Foster of the Zoology Department, University College, Nairobi, encouraged and assisted us in many ways, and to them we are grateful. Rudolph S. Wolff of radio station WIIA, University of Wisconsin deserves special credit for selecting and assembling the receiving equipment.

This research was conducted under the direction of R. A. McCabe, Chairman, Department of Wildlife Ecology, University of Wisconsin. Financial support was provided by grants from the Rockefeller Foundation New York, and the Wisconsin Alumni Research Foundation, Madison, Wisconsin.

LITERATURE CITED

Astley Maberly, C. T.
1966. Animals of East Africa. Hodder and Stoughton, London. 211 pp.

Atlas of Kenya
1959. The Survey of Kenya, Nairobi. First Edition.

Brynard, A. M. and U. de V. Pienaar
1960. Kruger National Park, Annual report of the biologist, 1958/1959. Koedoe 3:1-197.

Cochran, W. W., and T. E. Hagen
1963. Construction of collar transmitters for deer. Minnesota Mus. Nat. Hist. Tech. Rept. 4. 12 pp. (Mimeo).

Darling, F. F.
1960. An ecological reconnaissance of the Mara Plains in Kenya Colony. Wildl. Monogr. 5. 41 pp.

Dasmann, R. F. and A. S. Mossman
1962. Population studies of impala in southern Rhodesia. J. Mamm. 43:375-395.

Dice, L. R., and P. J. Clark
1953. The statistical concept of home range as applied to the recapture radius of the deer-mouse (*Peromyscus*). Univ. Michigan Contrib. Lab. Vert. Biol. 62. 15 pp.

Hayne, D. W.
1949. Calculation of size of home range. J. Mamm. 30:1-18.

Lamprey, H. F.
1963. Ecological separation of the large mammal species in the Tarangire Game Reserve, Tanganyika. E. Af. Wildl. J. 1:63-92.

Mohr, C. O.
1947. Table of equivalent populations of North American small mammals. Amer. Mid. Natur. 37:223-249.

Pratt, D. J., P. J. Greenway, and M. D. Gwynne
1966. A classification of East African rangeland, with an appendix on terminology. J. Appl. Ecol. 3:369-382.

Schenkel, R.
1966. On sociology and behavior of impala (*Aepyceros melampus* Lichtenstein). E. Af. Wildl. J. 4:99-114.

Simon, N. M.
1962. Between the sunlight and the thunder. The wild life of Kenya. Collins, London. 384 pp.
1962.

Verts, B. J.
1963. Equipment and techniques for radio-tracking striped skunks. J. Wildl. Mgmt. 27:325-339.

DISCUSSION

MR. FORDEN HUGHES (Maryland): Would rain have any effect on the range or the amount of activity—particularly, the time of day when the rain comes? I'm not too familiar with the weather pattern, but I think there might be times when it might rain every day for a period.

DR. ABLES: Yes, rains did affect activity, depending upon the season when the rains came. During the light general rains in November, it might rain all day and most of the night, too. The same is true for the heavy rains; however, some of the lighter rains came about at noon—in fact you could almost set your watch by them. I studied the impala particularly to see what was going on when it rained. During the light rains, the animals almost invariably would be lying down.

However, rains had an indirect effect on the animals in that rains occurring right after droughts would cause a general response in the vegetation, and the impala and other animals as well, would frequently feed the entire day.

MR. EARL F. PATRIC (New York): How accurate was the gear, and how was this accuracy determined?

DR. ABLES: Accuracy was determined by placing transmitters at distances of one-half to three miles in every 20° segment around each tower. We ended up with 360 radio fixes as a check for accuracy.

The mean error was 1.1° with a range from 0 to 7°. We had to do this because there were two sites on the study area that invariably produced aborrant fixes, and we tried to take this into consideration to determine exactly where the animals were.

The association with edges perhaps might have been higher, but at three miles, 1 or 2 degrees does not allow you to pinpoint an animal very precisely.

MR. ANDREW VANDANTE (Native Wildlife Service): You indicate the impala being a nocturnal feeder. Did any of your data indicate variations in the peak of actively as related to nocturnal illumination?

DR. ABLES: I'm sorry, I have nothing on that. I think you're referring to activity during periods of moonlight versus the periods of darkness. I would hasten to add that they were active during both periods at an approximate midnight peak. I don't want to imply that impala are nocturnal feeders. They are more or less crepuscular feeders. But this peak of activity at night, as far as I can determine, is associated mainly with feeding behavior.

MR. WILLIAM RUTHERFORD (Illinois): Are impala associated with the large migrations that we hear of?

DR. ABLES: The impala are not migratory; of course, they do make short trips of a few miles. While we were studying the impala the rains were rather good, and there were no serious droughts, so there was no reason for them to leave the area. However, they do make short trips of 10 to 12 miles or so, but they are not a migratory animal.

DR. LEE TALBOT (Smithsonian Institution, Washington, D.C.): Farther south in Kenya the impala maintain breeding herds or harem herds, and that type of activity occurs throughout the year except in the dryest part in August, and, in very wet years. Did you find that in your study area and, if so, did this affect the distribution and activity of the animals when breeding activity wasn't taking place and the males and females were all mixed up?

DR. ABLES: No, I didn't notice anything like that. I realize that I'm not answering your question directly because I don't know the answer. The social behavior of the animals was instrumental in determining the home-range size of some of the animals. Some of the males changed social status regularly, and these animals have the largest home-range. They seem to be more or less displaced. I'm not getting anthropomorphic here, but they wandered around a lot more than animals associated more or less permanently with herds.

In August, there were large numbers of males in bachelor herds, and we did not track at this time, unfortunately. Had we done so perhaps we would have determined some of the things you were asking about.

OPTIMUM YIELD IN DEER AND ELK POPULATIONS

JACK E. GROSS
Colorado Cooperative Wildlife Research Unit, Colorado State University, Fort Collins

This paper has three objectives: (1) to describe fecundity-rate changes that occur with density changes in deer and elk populations, (2) to show how these fecundity rates can produce dome-shaped yield curves, and (3) to show how dome-shaped yield curves may be used for producing maximum sustained annual harvests and maintaining a healthy balance between deer and elk populations and their food supply.

Leopold (1933) defined game management as "the art of making land produce sustained annual crops of wild game for recreational use." In this paper, annual crop is defined as annual harvest, and optimum yield is defined as the sustained, maximum number of animals that can be harvested annually. Leopold's sustained-annual crop principle has for 35 years been a cornerstone of wildlife management philosophy. The principle has not diminished in importance, but wildlife managers have perhaps failed to develop a full understanding and appreciation for wildlife production dynamics and yield relations. Such appreciation would enhance our understanding of population manipulation and perhaps would solve some chronic management problems. As Scott (1954) pointed out: "There seems to be an unfortunate and growing lag between the significant advances in knowledge of population phenomena, and their practical application in the field of game management." The intent of this paper is to offer a perspective of population phenomena that may shorten the lag.

The fecundity-rate patterns observed in the deer and elk populations used as examples in this paper may not apply to all deer and elk populations. Some populations occupy habitats which have been drastically altered by man, and some populations, particularly white-tailed deer in the Midwest, have adapted to artificial habitats resulting from man's cultural practices. Their fecundity-rate response to density changes may not follow the model described. However, the examples presented in this paper fit a common pattern which may give insight for a unifying biological concept. With modifications for regional pecularities, the concept may be adaptable as an applied management tool.

OPTIMUM YIELD IN FISHERY THEORY

The concept of obtaining optimum yield from animal populations by manipulation of population size was first stated explicitly about 50 years ago by the Russian biologist Theodore Baranov (1918, 1926). The substance of Baranov's theory is shown schematically in Fig. 1. Baranov commented on this theory as follows:

> As we see, a picture is obtained which diverges radically from the hypothesis which has been favored almost down to the present time, namely that the natural reserve of fish is an inviolable capital, of which the fishing industry must use only the interest, not touching the capital at all. Our theory says, on the contrary, that a fishery and a natural reserve of fish are incompatible, and that the exploitable stock of fish is a changeable quantity, which depends on the intensity of the fishery. The more fish we take from a body of water, the smaller is the basic stock remaining in it; and the less fish we take, the greater is the basic stock, approximating to the natural stock when the fishery approaches zero.
>
> Now the question is, how far can we go in the direction of increased catch, to the right of the figure shown? Here we must notice that a progressive increase in intensity of fishing, resulting in an ever smaller and smaller increase in catch, becomes, sooner or later, simply inefficient. Hence, the farther we move to the right in the figure, the smaller becomes the average age and weight of the fish caught.

Modern studies in the theory of fishing have shown in general that as the intensity of fishing increases, the size of the annual catch

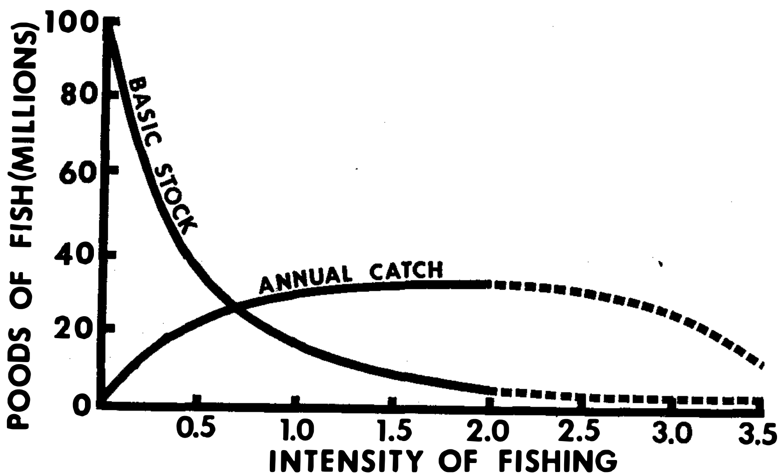


Figure 1.—Schematic representation of relation between size of basic stock, size of annual catch, and intensity of fishing. One pood equals 36 lb avoirdupois (solid lines from Baranov, 1918).

at first increases as breeding stock declines, but eventually decreases toward the baseline as breeding-stock numbers become small (Fig. 1). The extended relation between breeding-stock size and catch size indicated in Fig. 1 permits some elaboration on Baranov's ideas. First, only one value on the breeding-stock curve corresponds to the maximum annual catch that can be obtained from a population. That value lies between the minimum and maximum breeding-stock sizes that can be maintained by varying intensity of harvest. Second, catch size declines with harvest rates that adjust breeding-stock size to levels above or below the size where the maximum catch is obtained. Hence, if breeding-stock size is changed from some value where a certain size harvest is being obtained, the size of the harvest can either increase or decrease, depending on which way the breeding-stock size is adjusted. In this manner, identical annual catches can be obtained from two different breeding-stock levels.

Some deer and elk populations apparently conform, in terms of the net number of animals produced by the population per breeding period, to the basic optimum-yield concept in fisheries. Thus, maintenance of maximum annual harvest and maximum annual breeding stock are incompatible biologically, and therefore are incompatible management practices if optimum yield is the management goal.

OPTIMUM YIELD IN DEER AND ELK

Discussions of population-growth phenomena are usually introduced with an explanation of sigmoid-growth theory. Other demographic features may then be deduced from the existence of sigmoid growth. The opposite approach is taken in this paper by starting with the two basic components of population change, births and deaths, and inductively developing the mechanisms leading to optimum yield and sigmoid growth.

A conceptual model illustrating the effects of deer population densities on birth rates and death rates is shown in Fig. 2A. At lowest densities, births per unit of breeding stock are maximum and deaths per unit of breeding stock are minimum. As density increases due to positive net differences between birth rates and death rates, influences associated with increased density cause birth rates to slowly decrease and death rates to slowly increase. As population density further increases, the birth- and death-rate curves continue to converge and eventually meet. When births and deaths per unit of breeding stock are equal, the population ceases to grow.

The interaction of population size, births per unit of breeding stock, and deaths per unit of breeding stock will produce a dome-shaped net-population-production or yield curve (Fig. 2B). At lowest

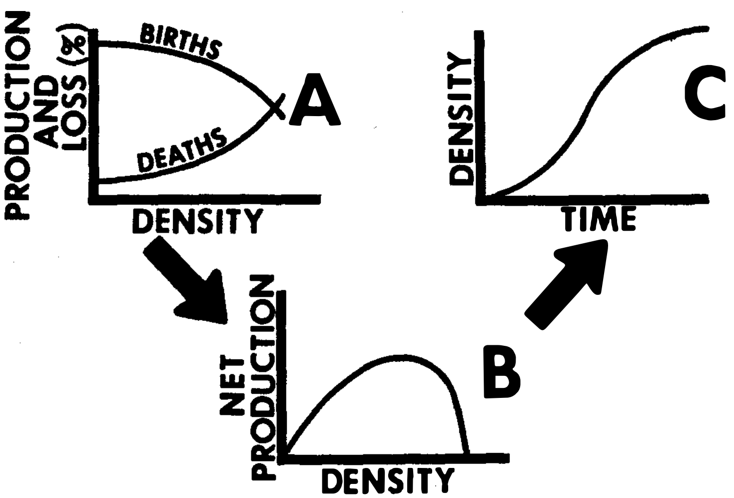


Figure 2.—Schematic representations of interactions between birth rates, death rates, net population production, and population growth (part A from Leopold 1955).

densities, net production per unit of breeding stock is maximum, but the net number of animals produced by the population is small because population size is small. As population size increases through lower densities, only small changes occur in the birth- and death-rate curves, and only small changes occur in net production per unit of breeding stock. Thus, the net number of young produced by the population (the product of net individual production times number of individuals producing) increases almost in direct proportion to breeding-stock size (Fig. 2B). As breeding-stock size increases and net production per unit of breeding stock simultaneously decreases (due to the increasingly rapid convergence of the birth- and death-rate curves), a certain combination of breeding-stock size and net number of young produced per unit of breeding stock will produce the maximum net number of young that can be obtained from the population. As the population density continues to increase and net production per unit of breeding stock continues to decrease, the net number of young produced by the population declines from the maximum value, and the dome-shaped yield curve is formed (Fig. 2B).

An S-shaped population growth curve is produced by the dome-shaped yield curve (Fig. 2C). The accumulation of yield values on the left side of the dome-shaped yield curve will produce the lower, concave portion of the population growth curve. The accumulation of yield values on the right side of the curve will produce the upper convex portion of the population growth curve. Conversely, if population growth follows an S-shaped form, the population must have an associated dome-shaped yield curve.

The shape of the birth- and death-rate curves need not conform precisely to those in Fig. 2A to produce the yield curve of Fig. 2B or the S-shaped growth form of Fig. 26. The criterion for the existence of a dome-shaped yield curve and an S-shaped growth curve is: either birth rates or death rates, or both, must decrease or increase, respectively, with increasing density so that the curves eventually meet. A dome-shaped yield curve would not exist if either birth rates or death rates, or both, converged instantaneously at densities where net population production was increasing.

Thus, Fig. 2 presents a conceptual framework that numerically and functionally integrates death rates, birth rates, yield, and population density. It remains to be shown that this conceptual framework exists in wild populations of deer and elk.

Fecundity-rate Patterns:

Dome-shaped yield curves probably occur in deer and elk populations because of the tendency for the number of young produced per female (and thus net production per female) to decrease with increasing population densities in a form similar to the birth-rate curve in Fig. 2A. Fecundity-rate patterns and the dome-shaped yield curve (net population production of young) will be demonstrated in deer and elk populations by combining information on population growth form with information on population fecundity rates. In this paper, fecundity is the production of ova, full-term fetuses or live young (Cheatum *et al.* 1950).

Fecundity rates (other than young-adult ratios) can be estimated for wild populations only by sacrificing animals. Such data are seldom obtained from populations too small to permit the removal of representative samples. Thus, fecundity-rate information for lower densities must be estimated from birth-rate and death-rate values that cause a population simulation model to generate growth forms and population sizes similar to those observed in wild populations. Fecundity rates for three elk and two deer populations are obtained in this manner. Population growth was simulated with a FORTRAN coded, computer population generation model recently developed at Colorado State University (Walters and Gross, unpubl. ms.).

Interpopulation differences in fecundity rates for populations at higher densities are commonly reported in deer and elk. These differences are generally associated with nutritional differences and thus may be associated indirectly with differences in population densities. Interpopulation comparisons of *differences* in fecundity rates that occur with *differences* in densities may support the thesis of this paper, but they do not show *changes* in fecundity rates that occur with *changes* in densities. As Scott (1954) suggested, the interplay between density, fecundity rates, and mortality rates develops different patterns between populations due to racial and local environmental characteristics. Thus, density-dependent effects are difficult to isolate in intrapopulation data. Few studies have been reported where densities and fecundity rates have been simultaneously measured on one population for a sufficient period of time to show patterns of change in fecundity rates with change in population density. Five examples (four deer populations and one elk population) showing changes in fecundity rates with change in density are described.

Low-density Fecundity Rates and Production Changes:

The George Reserve white-tailed deer (*Odocoileus virginianus*) herd was established from a plant of six animals (four does and two bucks) in a fenced enclosure of about 1,800 acres (O'Roke and Hamerstrom 1948). In six breeding seasons, from 1928 through 1933, the population grew from six to 160 animals (Fig. 3A). The average annual rate of population increase was about 60 percent per year. O'Roke and Hamerstrom (1948) suggested several fecundity-rate patterns which could have resulted in the 1933 density. The population could have reached its observed density in the six breeding seasons: (1) if 100 percent of 2-year-old or older does produced two fawns each, or (2) if less than 100 percent of the 2-year-old or older does produced fawns and a portion of the 1-year-old does produced fawns. These pregnancy rates were based on the assumption of no mortality. But since mortality probably occurred during the 6 years, the actual pregnancy rates must have been somewhat higher than those calculated by O'Roke and Hamerstrom. Since the adult fecundity rate was at its maximum, 1-year-old does undoubtedly contributed to the population growth. Although several combinations and values of age-specific fecundity rates could have produced the 1933 population, production of fawns during each of the six breeding seasons must have been at or near the maximum potential for the species. Thus, net population production must have increased almost linearly with population density.

The Seneca Army Depot white-tailed deer herd was created in 1942 when an estimated 20-40 deer were fenced within an enclosure of about 9,832 acres (Hesselton, 1965). Nothing is known of the deer densities from 1942 until 1947 when the first census accounted for 50 deer. If the original population-size estimate was correct, the population growth rate was relatively low during the first 5 years. During seven breeding seasons from 1948 through 1953, the herd increased

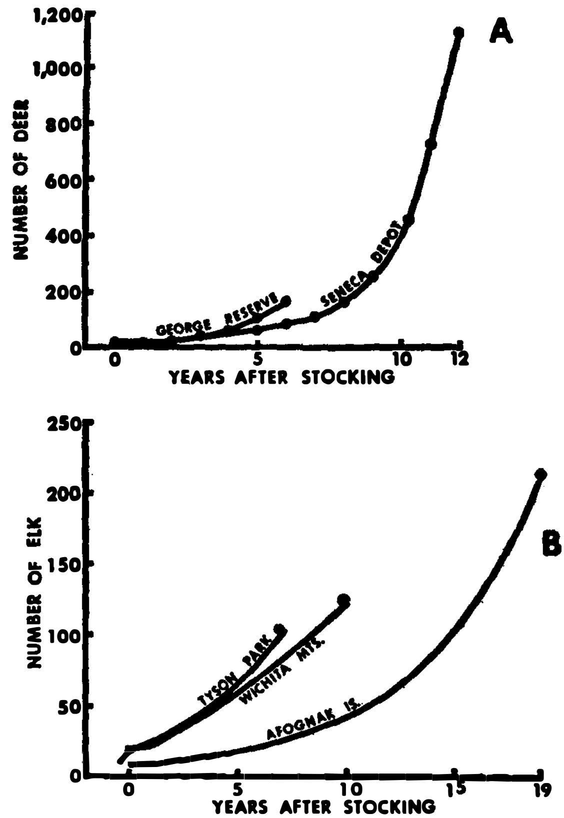


Figure 3.—Patterns and magnitudes of population growth in two deer and three elk herds following establishment of small herds (George Reserve from O'Roke *et al.*, 1948; Seneca Depot from Hesselton *et al.* 1965; Tyson Park from Murphy 1963; Wichita Mts. from Halloran 1962; Afognak Is. from Troyer 1960).

from 50 to at least 1,121 (Fig. 3A). The average population increase rate was 56 percent per year compared to 60 percent per year in the George Reserve herd. Thus the fecundity rate per female required to produce the observed herd increase was similar to that in the George Reserve herd. The rate of increase and population size could have occurred only if near-maximum fecundity rates were maintained for most of the growth period after 1947.

The Tyson Park elk (*Cervus canadensis*) herd in Missouri was established in February, 1951, with a transplant of two adult bulls and eight adult cows (Murphy, 1963). By October 1958, after eight reproductive periods, the herd had increased to 103 head (Fig. 3B). If no mortality occurred during the period of population growth, the herd could have reached its observed size with an annual adult cow pregnancy rate of about 80 percent. But Murphy concluded by inspection of the final age and sex ratio that mortality had occurred. The population fecundity rate must therefore have been higher than that provided by an 80 percent pregnancy rate in adult cows. Murphy calculated a theoretical population size of 142 at the end of eight reproductive periods, based on the following assumptions: (1) the original eight cows were pregnant, (2) only adult cows reproduce, (3) each adult cow produced a single calf, and (4) the sex ratio of the calves was even.

The computer model for this herd predicted that the assumption that only adult cows reproduced is not valid. If the herd was subjected to annual mortality rates of 10 percent for calves and 5 percent for older age classes, the herd could have grown to its observed size with annual pregnancy rates of 95 percent in adult cows and 60 percent in yearling cows. Even if the mortality-rate estimates are only approximate, the population must have increased at or near its maximum potential rate due to near maximum fecundity rates. Net population production must have increased almost linearly with population density.

The Wichita National Wildlife Refuge in the Wichita Mountains of Oklahoma was stocked in 1908, 1911, and 1912 with five bull and 16 cow elk (Halloran, 1962). The first reproduction occurred in 1913, and by 1922, the herd had increased to an estimated 125 head (Fig. 3B). By assuming the average annual adult mortality rate of 12 percent actually observed from 1925 to 1956 also applied to the earlier years of population growth, and by assuming an annual calf mortality rate of 10 percent as in the Tyson Park simulation, the Wichita herd could have increased to its observed population size with an annual pregnancy rate of 95 percent in adult cows and 30 percent in yearling cows. Thus, the Wichita Mountains elk herd also apparently grew near its maximum potential growth rate due to near maximum and constant fecundity rates. Net population production must have been similar to that of the Tyson Park elk herd.

In the spring of 1928, three bull and five cow elk calves were released on Afognak Island, Alaska (Troyer 1960). By December 1948, after 19 calving seasons, the herd had increased to an estimated 212 animals (Fig. 3B). By assuming the same annual adult and calf mortality rates as the Tyson Park herd and similar to the Wichita Mountains herd, the population could have grown to its observed size with annual pregnancy rates of 95 percent in adults and 30 percent in yearlings. The annual fecundity rates, net population production, and population growth rate of the Afognak Island elk herd were similar to the fecundity, production, and growth rates of the Tyson Park and Wichita Mountains elk herds.

Several conclusions follow from the five examples of deer and elk growth curves at low densities. First, although the assigned mortality rates for adults and young and thus the calculated pregnancy rates were approximate, all five populations apparently attained near maximum growth rates for the species and thus must have annually attained near maximum fecundity rates. Since constant fecundity rates were apparently maintained through increasing population sizes, the net number of young produced by the populations at any population size must have been directly proportional to that population size. Thus, as population sizes increased (lower part of the sigmoid curve in Fig. 3C), net population production of young increased in a manner similar to the left portion of the net-population-production curve (Fig. 3B).

High-density Fecundity Rates and Production Changes:

The effect of density on fecundity rates at higher densities has been determined in several instances by measuring fecundity rates during population-density changes. Examples below are restricted to populations in which density and fecundity rates were measured consecutively over a period of years, thereby permitting comparison of consecutive changes in fecundity rates with consecutive changes in population density.

Teer *et al.* (1965) measured ovulation rates on a white-tailed deer herd that declined to a density of nine deer per 100 acres and subsequently increased to a density of 18 deer per 100 acres. Ovulation rates were about 1.90 ova per adult doe and 1.60 ova per yearling doe at the lowest population density, and decreased to about 1.35 ova per adult doe and about 1.15 ova per yearling doe at the highest population density (Fig. 4A).

The Seneca Army Depot deer herd (see above) was opened to hunting in 1957, after the herd had increased to its highest density of 2,498 deer. Litter sizes were measured in 1,441 females harvested during five hunting seasons from 1957-1961. As the population decreased from 2,498 deer in 1957 to 263 deer in 1961, average litter sizes increased about 0.4 fetus in yearling and adults, and about 0.2 fetus in fawns (Fig. 4B).

O'Roke and Hamerstrom (1948) calculated fawn crops as the George Reserve deer herd grew from 6 to 210 and subsequently declined to 74 head. A regression of fawn-crop sizes on preceding early-winter population densities indicates an inverse relation between fecundity rates and population size (Fig. 4C). They concluded

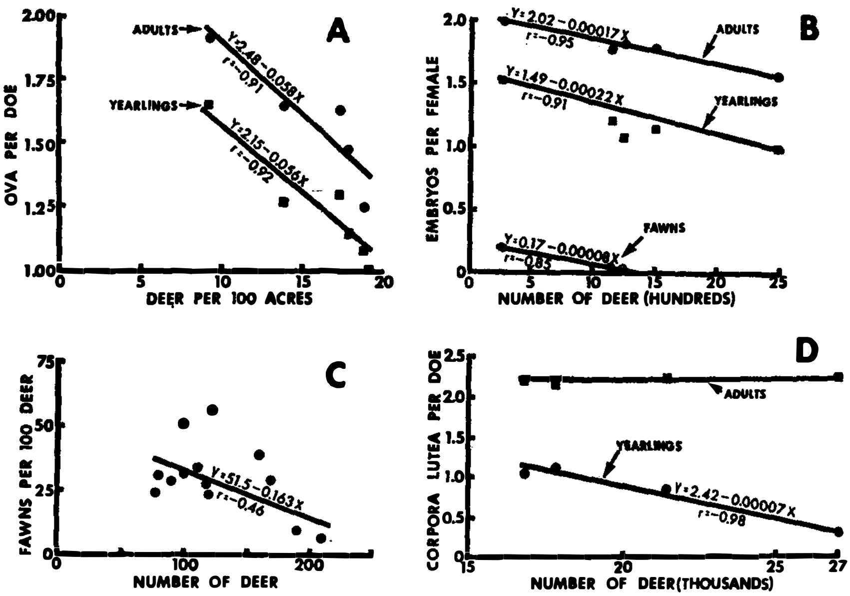


Figure 4.—Regressions of fecundity rates on population sizes in four deer herds (A from Teer *et al.* 1965; B from Hesselton *et al.* 1965; C from O'Roke *et al.* 1948; D from Swank 1958).

average reproductive rates were highest (about 60 percent) when the herd was first starting to increase from a small nucleus. The average reproductive rate was lowest (about 38 percent) during a 6-year period in which they considered deer to be over-abundant. During a 7-year period after the over-population was reduced, the average reproductive rate was intermediate at about 54 percent.

O'Roke and Hamerstrom (op cit.) made several suggestions that are of particular interest to the thesis of this paper: "Our findings suggest that the George Reserve herd, in the absence of natural predation and with inadequate hunting pressure—in both of which it is comparable to many wild herds—tended to become to some extent self-limiting after it developed an overpopulation." The trend of their thinking is further indicated: "Is there here a population mechanism which may forestall the final rise to an erruptive peak, and is the significant thing about deer erruptions not that they sometimes happen but that they happen so seldom? Does such a mechanism plus predation, rather than predation alone, hold wilderness deer in check? Is reproductive capacity violently upset by nutritional deficiencies shortly before wholesale deaths by starvation begin? Does the lesser degree of variation in rate of reproduction at the lower level of population indicate that psychological, rather than nutritional, causes are involved?"

The Kaibab North mule deer (*Odocoileus hemionus*) herd in part exhibited a density-dependent reproductive pattern somewhat similar to that described above for white-tailed deer populations. The population increased from an estimated 16,869 head in 1951 to an estimated 27,456 head in 1954 (Swank 1958). During this density increase, the corpora lutea rate decreased in yearling does from 1.55 in 1951 to 1.33 in 1955 (Fig. 4D). The adult corpora lutea rate did not appear to respond to increasing density as it did in the white-tailed deer populations. However, in Swank's original data some corpora lutea rates for adults exceeded an average of three per pregnant doe, which seems abnormally high.

Fecundity rates have apparently decreased with population density in the White River elk herd (Colorado) in a pattern similar to that described above for deer herds (Boyd, in press). The White River elk herd has steadily increased from an index density of about 2,100 in 1958 to about 3,800 in 1967. During this 10-year period of population increase, the calf-cow ratio has steadily declined from 71:100 to about 59:100 (Fig. 5).

The above five examples clearly suggest an inverse relation between fecundity rates and densities in deer and elk at higher densities. As a

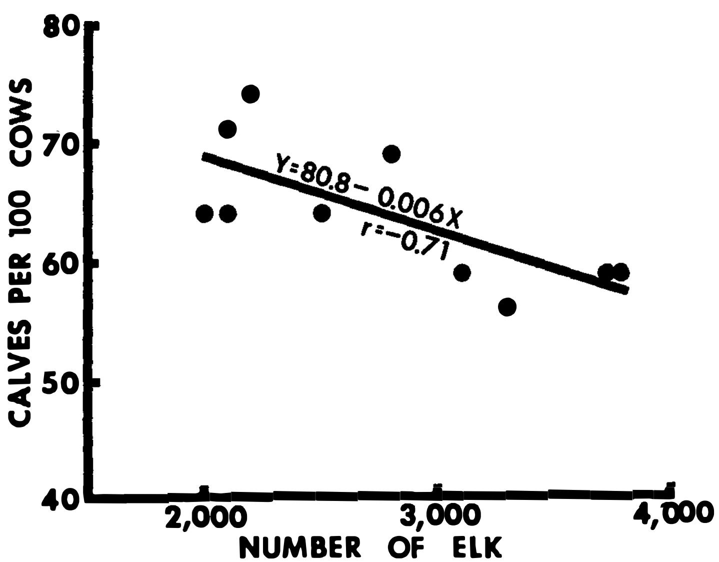


Figure 5.—Regression of fecundity rates on population size in the White River elk herd, Colorado (from Boyd, in press).

response to this inverse relation, the linear relation between population size and net population production of young at lower densities must become a pronounced curvilinear relation at higher densities. Also, as population densities increase and net production of young per individual declines, densities will be reached where the maximum net number of young will be produced by the populations. Beyond this point, net population production will decrease. Thus, the examples of changing population size and changing fecundity rates provide empirical support for the optimum-yield mechanism shown in Figs. 2A and 2B.

DISCUSSION

The principal management implication of the optimum-yield concept is that maximum annual production of young in most deer and elk herds can be obtained by keeping population densities below those which other management policies might dictate. If maximum annual harvest is the management goal, manipulation of the population to achieve maximum turnover rate should take precedent over manipulation of the population to achieve maximum size. Management efficiency is thus measured in terms of achieving maximum annual net production.

The optimum-yield concept also has a significant management implication for the management of deer and elk range. Perhaps the foremost deer and elk management problem is the maintenance of a healthy balance between populations and their food supply. Much has been written about the concept and problem of carrying capacity, but the concept continues to be vague and elusive for application in wildlife populations. Considerable time, effort, and money have been expended on attempts to measure changes in range conditions and browse production, which could be correlated with changes in population densities, with the objective to determine densities which the habitat could support. These efforts, however well directed, have been unsuccessful primarily because of the extreme complexity of the interactions between the population's food demand and the habitat's food supply.

Deer and elk management based on optimum-yield principles would not depend directly on population and food-supply measurements for fixing herd sizes. Population sizes which produce optimum yields are below densities where birth rates and death rates are normally balanced. If this natural balance point is at the population size that the range could support without inflicting adverse effects either on the range or on the population, then populations held at optimum-yield sizes cannot overbrowse or otherwise by direct use adversely affect the vegetation. Thus, if populations were maintained at or near optimum-yield densities, vegetative and density studies designed to relate food supply and demand would not be necessary for efficient management of deer and elk populations.

Another management implication in the optimum-yield concept is associated with the response of fecundity rates to density changes. As Scott (1954), Cheatum *et al.* (1950), Robinette *et al.* (1955), and many others have suggested, fecundity rates are readily modified by habitat conditions, and particularly by nutritional conditions. The nutritional changes are caused partially by the population's impact on the habitat and partially by factors external to the population. Thus, fecundity rates may be sensitive monitors of the total environmental impact on a herd's welfare as are measurements of body-fat, starvation rates, etc. But the latter are terminal symptoms of critical environmental conditions, while fecundity-rate changes are initial symptoms of the onset of potentially critical environmental conditions. Thus, fecundity rates of deer and elk populations may provide an indirect but objective measure of the relation between population density and food supply which direct measurements of population density and food supply have not provided.

Finally, the optimum-yield mechanism may provide an objective reference point for the adjustment of population densities. The relative position of a population's density in its higher range of densities can be estimated by comparing the fecundity rate for a population at a given density to the fecundity rate for the density which would produce optimum yield. Thus, regardless of whether a manager wanted to adjust a population to its optimum-yield density, he would have a method and an objective reference point for gauging herd-density changes and subsequent changes in the welfare conditions of the herd. Should habitat conditions change either from the effects of population density, or from the effects of extrinsic factors, either of which might not be detected with other techniques, changes in fecundity rates should provide an early warning of changes occurring in the balance between the herd and its habitat.

The experimental White River elk herd in Colorado provides an example of how the foregoing concepts might be applied. The regression of calf-cow ratios on population-index values (Fig. 5) indicates that some factor associated with increasing density is causing a constant decline in annual calving rates. If a partial cause of this decline is nutritional deficiency, then the growing population is exerting a progressively greater influence on its food supply and may ultimately produce the classical over-populated and over-browsed range. Studies of the habitat's food supply and the population's food demand probably would not demonstrate the progressive intra-specific competition indicated by the fecundity-rate pattern.

Production data from Fig. 5 and mortality data not presented in this paper (Boyd, in press) were used to develop a population simulation model for the White River elk herd. The model predicts that the population, at an index size of about 4,000 in 1967, will, under present harvest rates, reach an optimum-yield index size of about 6,000 in approximately 12 years. Projection of the regression in Fig. 5 indicates the annual fecundity rates will have decreased to about 44 calves per 100 cows at the optimum-yield index density. Thus, attainment of the population size that will produce the maximum annual yield and maintain a safe balance between food supply and demand can be identified from fecundity-rate measurements. Should a change in range conditions occur when the population is at a given size, the change in the balance of food supply and demand should be monitored and thus measurable by changes in fecundity rates.

SUMMARY

1. The basic concept of optimum yield, as expressed in the theory of fishing, is applicable to deer and elk populations: maximum population size and maximum harvest are biologically incompatible management goals.
2. Fecundity-rate responses to density changes in deer and elk populations appear to be density dependent at higher densities and thus provide the only mechanism necessary for populations to conform to the conceptual optimum-yield model.
3. In the deer and elk examples, birth rates (fecundity rates) and the net number of young produced per unit of breeding stock are maximum and relatively constant at low densities, and thus net population production of young increases proportionally with breeding-stock size.
4. Fecundity rates and the net number of young produced per unit of breeding stock declines at high densities, and thus total net production is decreasingly proportional to breeding-stock size.
5. The maximum net annual production of young by the population occurs when the product of increasing breeding-stock size and decreasing net production of young per unit of breeding stock is maximum.
6. Net annual production of young by the population declines as the population size continues to increase and net production per unit of breeding stock continues to decrease, thereby producing the dome-shaped yield curve.

7. The density that annually produces the maximum net number of young is below the density which the habitat could maintain.
8. At optimum-yield density, a population's demand for food is below the level where demand might tax the habitat's supply and thus nutritional crises are not likely to occur.
9. Fecundity rates appear to be a sensitive monitor of the balance between population food demand and habitat food supply, and may be used as discrete and reliable measures for manipulating a population to desired densities.

ACKNOWLEDGMENTS

I sincerely appreciate the stimulating discussions and critical comments offered by Carl J. Walters during the synthesis and writing of this paper. I am also indebted to Alex Cringan, Dale Hein, Fred A. Glover, and Allen Anderson for critical analysis of the manuscript.

LITERATURE CITED

Baranov, F. I.
1918. On the question of the biological basis of fisheries. Nauchny: issledovatelskii iktiologicheskii Institut, Izvestiia 1(1):81-128.

Baranov, F. I.
1926. On the question of the dynamics of the fishery industry. Biull. Rybnovo Khoziaistra for 1925.

Boyd, Raymond J.
The elk of the White River Plateau. In press.

Cheatum, E. L. and C. W. Severinghaus
1950. Variations in fertility of white-tailed deer related to range conditions. Trans. No. Am. Wildl. Conf. 15:170-190.

Halloran, Arthus F.
1962. History of the Wichita Mountains Wildlife Refuge elk herd. Proc. of the Okla. Acad. of Sci. p. 229-231.

Hesselton, William T., C. W. Severinghaus, and John E. Tanck
1965. Population dynamics of deer at the Seneca Army Depot. N. Y. Fish and Game Jour. 12(1):17-30.

Leopold, A.
1933. Game management. Charles Scribner's Sons, N. Y. 481 p.

Leopold, A.
1955. Too many deer. Scientific American 139(1):101-108.

Murphy, Dean A.
1963. A captive elk herd in Missouri. Jour. Wildl. Mgt. 27(3):411-414.

O'Roke, E. C. and F. N. Hamerstrom, Jr.
1948 Productive and yield of the George Reserve deer herd. Jour. Wildl. Mgt. 12(1):78-86.

Robinette, W. Leslie, Jay S. Gashwiler, Dale A. Jones, and Harold S. Crane
1955. Fertility of mule deer in Utah. Jour. Wildl. Mgt. 19(1):115-136.

Scott, Robert F.
1954. Population growth and game management. Trans No. Am. Wildl. Conf. 19: 480-504.

Swank, Wendell G.
1958. The mule deer in Arizona chaparral. Wildl. Bull. No. 3, Arizona Game and Fish Dept. 109 p.

Teer, James G., Jack W. Thomas, and Eugene A. Walker
1965. Ecology and management of white-tailed deer in the Llano Basin of Texas. Wildl. Mono. No. 15. 62 p.

Troyer, Willard A.
1960. The Roosevelt elk on Afognak Island, Alaska. Jour. Wlidl. Mgt. 24(1):15-21.

Walters, Carl J., and Jack E. Gross.
Determination of optimum yield in wildlife populations. Unpubl. Ms., Colorado State University.

DISCUSSION

DR. AARON N. MOEN (Cornell University): Deer and elk are highly mobile, both moving from one area to another and about a particular center of activity. You used the term "density" frequently. How do you identify "density"? How do you look at "density" when you can, in fact, have the same number of animals in a population but changing areas, which results in a continaully fluctuating density. What point in time do you look at density?

DR. GROSS: This is a good point and is something that carries a hidden implication. We have for years struggled with the task of trying to estimate densities in population. As Dr. Moen pointed out, density is a nebulous population parameter and is difficult to measure.

In the particular situations that I refer to, I used essentially the winter population densities that were responsible for a fawn crop or an ovulation rate the following spring. For this particular question, I see two answers. First, if the whole year is considered, these deer populations, particularly those in the West, are very mobile and a density figure in the summer means absolutely nothing.

Perhaps, even within seasons, density is a nebulous concept and hard to pin down. If we could develop this theory of optimum yield and our understanding of yield relations, we could in large part depart from this extreme necessity of obtaining absolute density figures of the regressions which were based on density figures and density as necessary for calculating the optimum yield point.

MR. DALE A. JONES (New Mexico): Some studies have shown that summer is more important than winter in deer production. Would it not be possible to have a completely overused winter range with an excellent summer range and still get high production?

DR GROSS: Yes, it certainly would. Of course, what I have presented here is a concept. There has been considerable discussion in literature that different stages of biology are affected by different summer and winter range conditions, and certainly, if summer range conditions contributed largely to fertility rates of the following breeding season, then the elements of summer range conditions would have to be figured in.

It's true that some authors consider summer range to be, perhaps, as important in determining fecundity rates as winter range conditions; and perhaps this is a good point to bring out. We are dealing with a complex subject here, but regardless of whether it's winter range or summer range, the input seems to be a sort of computerized process with a single output of fecundity rates. If we are dealing with a nebulous relationship between summer range and winter range conditions and their comparative effects on breeding, then it would appear we can look at just one value, and that is fecundity rates. I suspect that if we look at the stages of reproduction all the way from ovulation to parturition the effects of summer range conditions and winter range conditions might be isolated out.

MR. CURT HAMMIT (California): Jack, are we wasting our time and everything we have as far as utilization costs are concerned? Are you telling us that we better start looking at it in a different way?

DR. GROSS: Yes.

MR. HAMMOND: How do we do it?

DR. GROSS: There are several other papers coming out on this in the near future with much more detailed explanations and processing, and these yield functions will be explained. I'm not saying that range studies should be done away with. I would be all for them if someone would show me just one field study where the carrying capacity has been objectively defined and proved to exist with the approach that we have been taking for the past 20 or 25 years. I think we should take a new look.

SURVEY OF ANIMAL DAMAGE ON FOREST PLANTATIONS IN OREGON AND WASHINGTON[1,2]

HUGH C. BLACK
School of Forestry, Oregon State University

EDWARD J. DIMOCK, II
Pacific Northwest Range and Experiment Station, Forest Service, U.S. Department of Agriculture, Olympia, Washington

WENDELL E. DODGE
Bureau of Sport Fisheries and Wildlife, Olympia, Washington

WILLIAM H. LAWRENCE
Forestry Research Center, Weyerhaeuser Company, Centralia, Washington

The Cooperative Animal Damage Survey (CADS) was begun to study the kind, amount, distribution, and significance of damage by mammals and birds to Douglas-fir and ponderosa pine plantations in Oregon and Washington. The survey samples the Douglas-fir and ponderosa pine regions of the Pacific Northwest; sampling plots are randomly located, regardless of damage potential or land ownership. Findings will be projected from actual growth and survival on sampled plantations over a 5-year period (Dimock and Black, 1968). Results will assist in estimating long-term losses caused by animals on such plantations.

Foresters in Oregon and Washington are increasingly concerned and perplexed by animal damage to timber crops, especially to seedling, sapling, and pole stands. During stand development on forests west of the Cascade Mountains, young Douglas-fir (*Pseudotsuga menziesii*) are typically subjected to injuries by small rodents (*Microtus* sp., *Clethrionmys occidentalis, Neotoma* sp.), sooty grouse (*Dendragapus obscurus*), mountain beavers (*Aplodontia rufa*), snowshoe hares (*Lepus americanus*), brush rabbits (*Sylvilagus bachmani*), deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), livestock, and black bears (*Ursus americanus*). East of the Cascades, ponderosa pine (*Pinus ponderosa*) are damaged by jackrabbits (*Lepus townsendii* and *L. californicus*), snowshoe hares, pocket gophers (*Thomomys* sp.), deer, elk, livestock, and porcupines (*Erethizon dorsatum*) before reaching maturity.

The seriousness of animal damage, defined as the result of any animal activity that reduces or delays total forest yield (Dimock and Black, 1968), has been long recognized in this region. Moore (1940) described forest practices in the Douglas-fir region and their relation

[1]Paper 672, School of Forestry, Oregon State University, Corvallis, Oregon 97331.
[2]The authors are conducting the survey as members of the Technical Sub-committee of the Animal Damage Survey (CADS) Committee, in coordination with the Northwest Pest Action Council and the Western Forestry and Conservation Association.

to wildlife, the animals that affect growing trees, the types of damage they cause, and their influence on forest regeneration. Lawrence (1958) emphasized the ecologic relations between wildlife damage and the pattern of forest regeneration. He estimated annual losses to Douglas-fir growing stock on tree farms of Weyerhaeuser Company as nearly $800,000 in plantations and young reproduction, and $100,000 in older age classes.

Forest management practices in the Pacific Northwest, principally logging and fire, profoundly affect populations of forest wildlife (Moore, 1940; Lawrence, 1958; Crouch, 1968; Hermann, 1968; Oregon State Game Commission and Oregon State Board of Forestry, 1968). These wildlife populations, in turn, strongly affect the establishment and development of succeeding tree crops. In addition to soil disturbance during logging, site-preparation practices such as burning of slash, scarification (mechanical removal of slash and debris), planting of conifers, application of herbicides, fertilizing, and thinning all cause changes in vegetative composition and density, which in turn influence the number and condition of animals. About 255,000 acres of commercial forest land are logged and burned each year in the two states (Payne, 1964), and an estimated backlog of 2 million acres of forest land is in need of rehabilitation.

Forest management in the Pacific Northwest is becoming more intensive, and reforestation in the region has increased rapidly during the last 20 years (U.S. Dept. of Agric., 1967). In 1962, artificial reforestation was attempted on nearly 205,000 acres—about equally divided between direct seeding and planting. Expenditures for reforestation in Oregon and Washington rose from $800,000 in 1949 to more than $7½ million in 1962 (Payne, 1964).

FACTORS THAT INFLUENCE ANIMAL DAMAGE—RELATION TO SAMPLING INTENSITY

The relations of animal numbers to animal damage are highly complex. Commonly, wildlife species may occur on a plantation in large numbers but do no damage or only neglible damage to trees. Studies on Vancouver Island, British Columbia (Smith and Walters, 1964), and in western Oregon (Crouch, 1968) indicate that the rate and intensity of browsing are affected by deer numbers, weather conditions, elevation, forage availability, and many other environmental factors. Harper (1968), in a study in southwestern Oregon, reported that the use of conifers by Roosevelt elk (*Cervus c. roosevelti*) was influenced by age of logged areas, treatment of logging debris (burned or unburned), type of logging, habitat type, and proximity to cover.

Damage is seldom distributed uniformly throughout a plantation. For example, even with 110 deer per square mile within a fenced area in western Oregon, Douglas-fir trees on certain sites received little browsing in winter (Ore. State Game Com. and Ore. State Bd. of For., 1968). Smith and Walters (1964) also reported that deer damage on Douglas-fir plantations on Vancouver Island was concentrated in areas that seldom exceeded 2 acres. Harper (1968) noted that 95 percent of the Douglas-fir browsed seriously by elk were in areas adjacent to standing timber. Only 3 percent of the problem-areas were more than 300 yards from timber.

These factors were considered in planning the survey, and they influenced our decisions on sampling intensity and on the complete randomization of sampling. We did not stratify our sampling because the distribution of wildlife species and patterns of conifer use were not known in the detail required.

THE SURVEY

Planning the Survey:

Early in 1960, the Northwest Forest Pest Action Council's Committee on Forest Wildlife Problems requested assistance from the Pacific Northwest Forest and Range Experiment Station in designing a survey to inventory animal damage in forest stands. A problem analysis prepared by Pope[3] provided initial guidelines. In January, 1963, the Station completed a survey plan and submitted it to the Committee (Herman *et al.,* 1963). Although animal damage occurs in forest stands of all ages, the proposal was limited to measuring the effects of animals on newly established plantations of Douglas-fir and ponderosa pine. The plan was reviewed and accepted by the full Committee in May, 1963.

An action committee (CADS) was then appointed and charged with the responsibility of implementing the survey and reporting the results. The Committee made the following major revisions in the plan: 1. Companies planting fewer than 50,000 trees per year were excluded from the survey. 2. The rate of sampling was increased from one plot per million trees planted to one per 500,000 trees planted. 3. The number of protected seedlings on each plot was increased from 5 to 10. 4. All re-examinations and remeasurements of plots were to be accomplished by a small group of professionals—headed by the Technical Subcommittee. 5. The sample size was expanded by replicating the survey in a second planting season to increase reliability of the survey.

[3]Pope, Robert B. Preliminary suggestions concerning an inventory of animal damage to forest lands of the Pacific Northwest. October 12, 1961.

PROCEDURES

The general plan was to establish 207 sampling plots randomly located within Douglas-fir and ponderosa pine plantations to be planted in Oregon and Washington in 1963-64 (116 plots) and in 1964-65 (91 plots). Only those forestland owners planting 50,000 or more seedlings during 1962-63 or 1963-64 were considered as potential participants in the survey. Plantations east of the Cascades were not sampled in the second planting season.

Each sampling plot was to consist of 110 newly planted seedlings, 10 of which were to be caged to protect them from animal-caused injuries. Caged seedlings were to be controls for evaluating survival and growth of unprotected seedlings. Total heights and occurrences of animal damage were to be recorded annually for 5 years.

A master list of potential cooperators was compiled from data obtained from forest nurseries in the region. Cooperators were then drawn at random. Fourteen major organizations and six small companies were selected.

Sampling Plots:

Cooperators were instructed to select planting areas immediately after assignment of plots to assure equal probability of selection from among all units to be planted to Douglas-fir, ponderosa pine, or a mixture of the two species. Plots were randomly located by cooperators. Procedures were outlined in training sessions for locating starting points of sampling plots by random coordinates. Typically, each sample consisted of four rows of staked seedlings (3 rows with 27 seedlings each and 1 row with 29 seedlings) that formed a long, narrow, rectangular plot. Seedlings were marked individually with numbered stakes, and each sampling plot was identified with a roadside post and marker.

Caging Control Seedlings:

Ten of the 110 seedlings on each sampling plot were caged to protect them from wildlife. Each tenth seedling was screened, ending with tree 100. Cages were of wire netting with 1-inch mesh in the form of a cylinder 3 feet in diameter and 4 ft in height. Stakes supported the screens. Crews were instructed to install cages perpendicularly on slopes, to cut the wire netting to conform to the slope where needed, and to avoid unnecessary disturbance of the planting spot.

Of 207 sampling plots assigned to cooperators, 194 (or 94%) were installed in two series—112 on 1963-64, and 82 in 1964-65. Failures to install some plots were caused by changes in planting schedules that resulted from adverse weather and by the inability of some companies to participate.

Planting dates extended from December through mid-June in both planting seasons. Lack of access or unsuitable planting conditions caused by persistent snow cover at higher elevations in 1964 resulted in some planting and plot installation being accomplished in late spring. This delay resulted in wide variation in the length of time that certain plots were exposed to animal influence—it also adversely influenced survival of certain plantations. At high elevations, mainly on national forests and BLM districts in southern Oregon, re-examination of certain plots in 1964 followed closely after installation.

A preponderance of plots (73 percent) is in Oregon, with most plots in both states (85 percent) on public lands: 73, Forest Service; 54, Bureau of Land Management; 26, Oregon State Department of Forestry; and 10, Washington Department of Natural Resources. By species, 165 plots (85 percent) are in Douglas-fir plantations, 4 plots are in mixed Douglas-fir and panderosa pine, and 25 plots are in ponderosa pine, Jeffrey pine, or a mixture of the two.

Plot Examination:

Height of seedlings at planting was measured by each cooperator following plot installation so that height losses caused by animal feeding could be determined when seedlings were re-examined. Heights at planting were recorded to the nearest one-half inch—subsequent measurements were recorded to the nearest inch. Standardized measuring procedures were outlined, which included instructions to measure seedlings on the north side next to the stake and to measure height to the tip of the terminal bud. Forms were provided for recording heights and supplemental information pertaining to location of plantation, locality of sampling plot, planting stock (species, age, nursery, lot number, seed source, elevation of seed source, date of lifting, date planted, condition of stock, spacing, new planting or replanting, quality of planting, and animal-repellent treatment on stock), history of planting area, and site data (years deforested, slash burned or unburned, wildfire history, site preparation, elevations, aspect, slope, and site classification).

Re-examinations of plots and analyses of the data are being done cooperatively by representatives from four organizations—Weyerhaeuser Company, the U.S. Bureau of Sport Fisheries and Wildlife, the U.S. Forest Service, and Oregon State University. Each member of the Subcommittee assumed responsibility for examining an assigned group of plots. This procedure facilitates the examinations and assures continuity in observations. Examinations are made annually after bud burst during spring and summer.[4]

Each annual observation period is from bud burst to bud burst to represent one year's growth, with the exception of the first examination after planting, which extended from planting date to bud burst. Height measurements, which are usually made during the growing season, are made from the ground to the base of new terminal leaders—current growth is not measured. Photo points are located on plots and a photographic record is maintained annually for most plots.

Examinations are timed to follow bud burst rather than to occur at the end of the growing season, because on the average more serious damage occurs during the dormant season, and this damage is more difficult to detect and to identify in the fall. Also, many seedlings die after being damaged. Dead seedlings are often difficult to locate, and if found, the type of injury may be hard to interpret. Terminology in the illustrated guide to the identification of wildlife feeding injuries on conifers in the Pacific Northwest (Lawrence, *et al.*, 1961) is followed in classifying animal-caused injuries to seedlings.

Data Processing:

Notes are recorded on permanent field notebooks and subsequently transcribed onto OMR (optical mark reader) forms for automatic data processing. Preliminary programming provides print-outs that summarize types of damage and damage agent and status of caged and uncaged seedlings in each sampling plot (number of trees live and dead, and number of each category damaged and undamaged; number of trees missing; number of stakes missing; average height of live undamaged and damaged trees; and average height of all trees). Appropriate data are expressed numerically and in percentages. Printed copies of summarized data sheets are provided cooperators each year for sampling plots on their lands.

RESULTS

Table 1 summarizes mean survival of caged and uncaged seedlings in both series of sampling plots for each year through 1968. Dead seedlings, damaged or undamaged by wildlife, and missing seedlings were included in mortality. Mean occurrence of animal damage on live, uncaged seedlings for both series of plots is summarized in Table 2. More trees were damaged by animals each year, but animal-

[4]Three ponderosa pine plots in eastern Oregon were not examined in 1964, and four Douglas-fir plots in Washington were not examined in 1965. One Douglas-fir plot in Oregon was destroyed by fire in 1966 and was not examined in 1967 and 1968.

TABLE 1. MEAN SURVIVAL OF CAGED AND UNCAGED SEEDLINGS ON SAMPLING PLOTS, IN PERCENT. (DEAD SEEDLINGS DAMAGED AND UNDAMAGED BY WILDLIFE, AND MISSING SEEDLINGS ARE INCLUDED IN MORTALITY.)

Plantation	State	Number of plots	Caged trees					Uncaged trees				
			1964	1965	1966	1967	1968	1964	1965	1966	1967	1968
			FIRST SERIES									
Douglas-fir	Oregon	70	90.1	80.1	78.3	76.0	72.8	86.1	66.7	62.4	59.1	55.8
	Washington	24	94.5	86.5[1]	81.3	81.6	79.6	95.0	79.0[1]	74.0	72.6	70.9
	Both	94	91.2	81.8[1]	79.1	77.4	74.5	88.3	69.8[1]	65.2	62.6	59.7
Ponderosa pine	Oregon	13	99.2	91.6	84.7	82.6	77.5	97.8	70.0	57.7	51.1	44.8
	Washington	3	100	93.3	93.3	93.3	93.3	100	92.3	89.7	86.7	84.8
	Both	16	99.4	91.9	86.3	84.6	80.4	98.2	74.2	63.7	57.8	52.2
			SECOND SERIES									
Douglas-fir	Oregon	46	—	79.4	71.7	68.9	67.6	—	78.5	62.7	58.0	54.6
	Washington	25	—	90.3[1]	81.3[1]	80.3	79.3	—	86.8	72.1[1]	68.0	65.0
Pines[2]	Both	71	—	83.1[1]	75.0[1]	72.9	71.7	—	81.4	65.9[1]	61.5	58.2
	Oregon	9	—	88.9	78.9	74.4	69.8	—	88.1	71.8	59.2	55.6

[1] Data for one plot omitted in calculation of this mean value.
[2] Ponderosa and Jeffrey pines, pure and mixed.

TABLE 2. MEAN OCCURRENCE OF ANIMAL DAMAGE ON LIVE, UNCAGED SEEDLINGS ON SAMPLING PLOTS, IN PERCENT.

Plantation	State	First series						Second series				
		Number of plots	1964	1965	1966	1967	1968	Number of plots	1965	1966	1967	1968
Douglas-fir	Oregon	70	9.4	35.6	30.4	39.9	29.5	46	6.1	41.4	36.0	29.3
	Washington	24	6.2	33.2	33.5[1]	35.8	32.1	25	5.8	33.8[1]	33.2	37.6
	Both	94	8.6	35.0	31.1[1]	38.8	30.2	71	6.0	38.8[1]	35.0	32.2
Pines[2]	Oregon	13	7.8	20.2	22.2	13.2	17.6	9	4.8	16.7	1.7	7.2
	Washington	3	1.0	3.7	4.7	4.0	5.3	—	—	—	—	—
	Both	16	6.5	17.1	18.9	11.4	15.3	—	—	—	—	—

[1] Data for one plot omitted in calculation of this mean value.
[2] Ponderosa and Jeffrey pines, pure and mixed.

TABLE 3. MEAN HEIGHT AND STANDARD DEVIATION (BELOW EACH HEIGHT) IN INCHES OF LIVE SEEDLINGS IN THE FIRST SERIES (1963–64) AND SECOND SERIES (1964–65) OF SAMPLING PLOTS.

Plantation	State	Number of plots	Caged trees						Uncaged trees[1]					
			1964[2]	1964	1965	1966	1967	1968	1964[2]	1964	1965	1966	1967	1968
FIRST SERIES														
Douglas-fir	Oregon	70	8.3	8.2	9.7	13.8	20.8	30.4	8.3	8.2	8.7	10.6	14.6	21.2
			2.2	2.7	3.3	5.0	9.5	15.2	2.0	2.1	2.2	3.3	6.4	10.8
	Washington	24	9.4	10.6	10.6	17.3[3]	28.0	40.9	9.2	10.4	9.6	13.0[3]	20.1	29.9
			3.9	5.3	5.3	9.5	14.2	21.3	3.8	5.0	4.4	6.2	9.3	13.5
	Both	94	8.6	8.8	10.0	14.7[3]	22.6	33.1	8.5	8.8	8.9	11.2[3]	16.0	23.4
			2.8	3.7	3.9	6.6	11.2	17.5	7.6	3.2	2.9	4.3	7.5	12.1
Ponderosa pine	Oregon	13	4.0	4.1	4.7	6.9	10.0	14.8	4.0	4.0	4.4	5.2	7.0	10.3
			1.3	1.3	1.4	2.1	3.3	5.3	1.3	1.3	1.2	1.7	3.1	5.1
	Washington	3	6.8	7.4	6.1	7.1	12.6	21.2	6.7	7.4	5.7	6.5	11.0	19.6
			3.4	2.2	0.9	2.9	5.7	14.2	2.9	1.7	1.0	2.6	5.8	14.6
	Both	16	4.5	4.7	5.0	6.9	10.5	16.0	4.5	4.6	4.6	5.5	7.8	12.0
			2.0	2.0	1.4	2.2	3.7	7.5	1.9	1.9	1.2	1.8	3.8	8.0
SECOND SERIES														
Douglas-fir	Oregon	46	—	8.9	8.8	10.1	15.0	23.1	—	8.8	8.7	8.9	12.0	17.5
				3.2	3.3	3.3	4.8	7.4		3.1	3.1	2.9	3.9	6.6
	Washington	25	—	11.8	11.6	13.1[3]	19.3	29.4	—	11.6	11.6	11.8[3]	15.5	23.0
				6.6	6.9	6.7	9.5	15.0		6.2	6.0	5.8	7.5	11.7
	Both	71	—	9.9	9.8	11.1[3]	16.5	25.3	—	9.8	9.7	9.9[3]	13.2	19.4
				4.8	5.0	4.9	7.1	11.0		4.6	4.5	4.3	5.7	9.0
Pines[4]	Oregon	9	—	4.8	4.7	4.9	8.3	10.2	—	4.8	4.7	5.1	7.1	9.4
				1.0	1.0	2.2	4.1	7.3		1.1	1.1	1.2	3.8	5.9

[1] Both damaged and undamaged.
[2] Height when planted.
[3] Data for one plot omitted in calculation of this mean value.
[4] Ponderosa and Jeffrey pines, pure and mixed.

damaged seedlings that died during the year of examination are not included in these data. Table 3 shows the mean height of caged and uncaged seedlings of both series of sampling plots.

Survival:

Important differences were noted in seedling survival as related to region, species, planting season, and caging. The greatest amount of mortality within one year's observation period was recorded after the first full growing season. But considerable mortality, unrelated to animal damage, occurred soon after planting. Average mortality of all Douglas-fir undamaged by animals at time of the first examination after planting was 10.8 percent for the first series of plots and 17.8 percent for the second series.[5]

After four growing seasons, survival of uncaged seedlings in the first series averaged 60 percent for Douglas-fir and 52 percent for pines. Average survival of uncaged seedlings in the second series after only three growing seasons was similar for Douglas-fir (58 percent), but higher for pines (56 percent). Several plantations were either complete or partial failures.

Initial mortality among seedlings in the first series of sampling plots (1963-64 planting) was lower in all plantations than mortality occurring in the second series. Survival probably was influenced by differences between the growing seasons in 1964 and 1965. Unseasonably warm weather and drought during the spring and summer of 1965 possibly caused the higher mortality. Variations in the quality and handling of stock in the two planting seasons may also have influenced survival. Survival of Douglas-fir was better in Washington than in Oregon. Better sites on the average and more favorable growing conditions in Washington may explain this difference.

Survival of uncaged trees was lower than for caged trees, and this disparity is continuing to increase (Figure 1). For example, in 1968, survival of caged Douglas-fir seedlings in the first series of plots was 75 percent as contrasted to 60 percent for uncaged seedlings. And in the same year, survival of caged ponderosa pine seedlings in the first series of plots was 80 percent as contrasted to 52 percent for uncaged seedlings.

We recognize that the caged seedlings may not represent a completely unbiased estimate of tree performance, because some disturbance of planting spots accompanied installation of certain cages, and the caging may have affected growth. Also, in a few instances, animals damaged seedlings within the cages. The principal effect of caging

[5]Black, Hugh C. and William H. Lawrence. 1965. Second Progress Report of the Cooperative Animal Damage Survey of Forest Plantations in Oregon and Washington. CADS Committee, Northwest Forest Wildlife Relations Council. 5 p

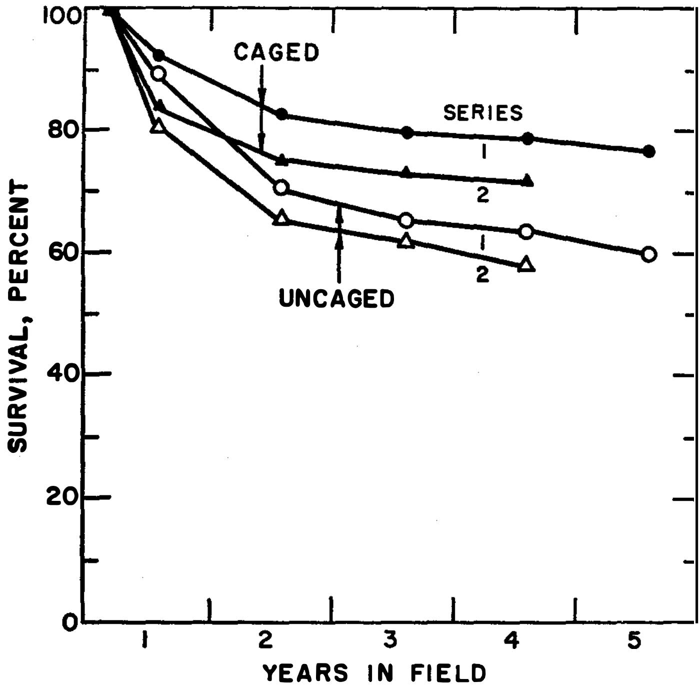


Figure 1.—Mean survival of caged and uncaged Douglas-fir seedlings in both series of sampling plots in Oregon and Washington. Both curves originate at the mean planting date of seedlings planted in 1963-64 in the first series and in 1964-65 in the second series.

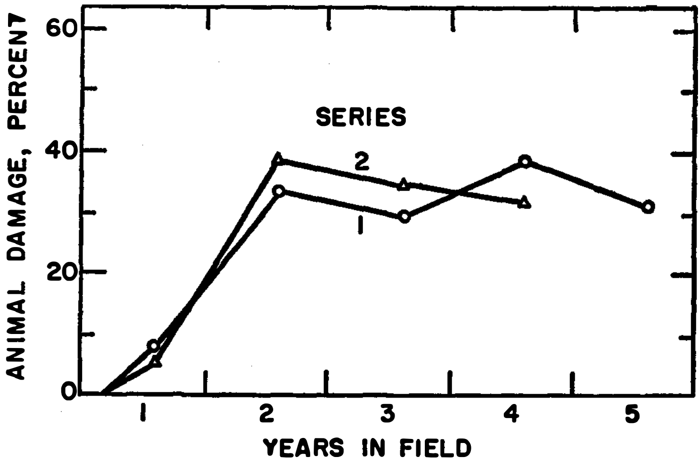


Figure 2.—Mean occurrence of animal damage on live, uncaged Douglas-fir seedlings on sampling plots in Oregon and Washington. Both curves originate at the mean planting date of seedlings planted in 1963-64 in the second series. The first examinations were made in the summers after planting in 1964 and 1965.

that we observed, however, was the greatly increased growth of herbaceous and woody vegetation within cages where it was protected from all feeding.

Animal damage:

Animal damage of some type and in some degree was recorded on two-thirds of all plots in both series at the first examination. In subsequent examinations, damage by animals was recorded on the average on 90 percent or more of all Douglas-fir plots. Mean damage on ponderosa pine plots in the second series occurred annually on about 75 percent of all plots. Roughly, one out of every three surviving Douglas-fir seedlings was damaged each year. Injuries from deer occurred on most of the damaged plots in each year of the survey (Figure 2).

Animal damage, in concert with other factors, markedly reduced height growth of unprotected seedlings (Table 3). For example, after 4 years, mean height of uncaged Douglas-fir trees on sampling plots in the first series in Oregon and Washington was 23.4 inches, compared with mean height of caged seedlings of 33.1 inches. Furthermore, growth losses caused by animal damage are increasing each year (Figure 3).

No important differences in mean growth of Douglas-fir or of ponderosa pine seedlings were noted in the two series. However, height of all seedlings when planted was higher in the second series (1964-65 plantings), especially in Washington. Average planted height of Douglas-fir seedlings on 24 plots planted in Washington in 1963-64 was 9.4 inches and on 25 plots planted in 1964-65 was 11.8 inches. Pine seedlings were smaller when planted and grew at a slower rate than Douglas-fir seedlings in both series.

The average number of seedlings damaged on all plots increased markedly at the second examination of both series of plots. This increase is probably related to protection the first winter by the treatment with TMTD that most seedlings received at the nursery, and to the year-long exposure to animal damage (the first examination had been made on the average about 3 months after planting).

Importance of Damage:

The nature, degree, and amount of damage must be evaluated in ranking animals in order of their destructiveness to reforestation in the region. Some kinds of damage are extremely limited in occurrence, such as that caused by moles (*Scapanus townsendii*) and pikas (*Ochotona princeps*). Conversely, hares and brush rabbits are widely distributed, and the amount of clipping injury recorded is substantial. But in most instances, damage consists only of clipping small lateral branches. Surprisingly, no serious damage by snowshoe hares has been counted on any of the sampling plots. Other animals, such as mountain beavers, pocket gophers, and porcupines are widely distributed, and damage characteristic of each species caused high mortality, or greatly suppressed the growth of surviving trees that had been damaged. These animals are rated as important regionally and a serious threat to regeneration locally where populations are abundant or conditions are conducive to damage, even though the occurrences of damage were a comparatively small percentage of the total recorded.

Browsing by deer was the most common damage by animals on all plots. Deer damage—mainly browsing of terminal or lateral branches, both during periods of rapid growth and during the dormant season—represented about 56 percent of all occurrences of damage recorded by agent in 1968. Levels of deer damage were comparable each year.

Based on current findings of the survey, deer rank first in frequency as an agent damaging to reforestation in the region. Other animals that caused damage, by frequency of damage in 1968, were hares and rabbits, elk, grouse, mountain beaver, pocket gophers, domestic stock, and porcupines. Insignificant amounts of damage were caused by pikas, microtine rodents, and moles.

The types of tree damage are closely correlated with the occurrences of damage as recorded by animal species. Browsing of foliage—mostly by big game and domestic stock—greatly exceeded all other types of animal-caused damage combined. Clipping of stems and of lateral branches, mainly by hares and rabbits, mountain beavers, porcupines, and pocket gophers, was next in order of occurrence. Budding, exclusively by grouse, ranked after browsing and clipping in order of occurrence on Douglas-fir plantations sampled in 1968. No budding was recorded on pine plots. Of all the other types of damage identified on Douglas-fir (barking, clipping of roots, pulling seedlings, trampling, and miscellaneous) each accounted for less than 1 percent of damage occurrences tabulated.

On pine plantations, however, clipping of foliage occurred more often than browsing in some years, and barking—mainly by porcupines and pocket gophers—represented about 10 percent of all occurrences. Damage by pocket gophers was recorded more often than damage by any other agent on the first series of sampling plots on pine plantations in 1968, but deer accounted for about two-thirds of animal-caused damage on the second series of pine plots.

Examples of Animal Damage on Sampling Plots:

Significant damage to planted seedlings mostly occurred in two

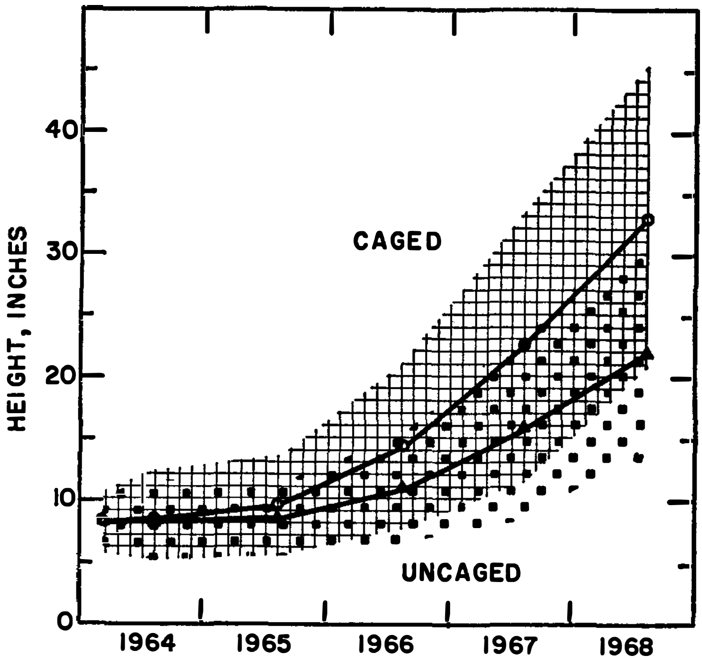


Figure 3.—Mean height and standard deviation of live Douglas-fir seedlings in the first series of sampling plots in Oregon and Washington. Both curves begin with the mean planted height, at the mean planting date. The first remeasurements were made in the summer after planting.

ways:[6] (1) seedlings were killed, usually as a result of clipping of stems or roots, or by the pulling of seedlings out of the ground; or (2) growth of seedlings was suppressed significantly because of extensive and repeated browsing or clipping injuries—this source of damage is of predominant importance. The first type of damage becomes significant when the extent of damage is sufficient to reduce stocking below an acceptable level, so that productivity is reduced (Grah, 1960) or reduces stocking so much that replanting is required. Both types of extreme damage to plantations are illustrated by the case histories of animal-caused mortality on plot 82, and by animal-caused suppression of height growth on plot 32.

Plot 82. Three-year-old, repellent-treated ponderosa pine seedlings were planted in April 1964 on plot 82 in central Oregon. The plantation is located on a burned site of low quality for ponderosa pine. The plantation is within a large fenced exclosure, which protects

[6]Hugh C. Black, Wendell E. Dodge, William H. Lawrence, and Edward J. Dimock II. 1968. Third progress report of the cooperative animal damage survey of forest plantations in Oregon and Washington. CADS Committee. 11 p.

the seedlings from deer, but does not exclude porcupines, hares, or pocket gophers. A bulldozer was used to scalp spots 10 by 10 feet for planting clusters of five seedlings each.

Initial survival of seedlings was good and very little animal damage was observed in the summer of 1964 (Figure 4). Pocket gophers were active on the sampling plot, but did not damage seedlings during the first year. In 1965, many seedlings had been clipped by porcupines and pocket gophers, which resulted in death of many seedlings. Cattle used the area in 1966 and may have trampled or browsed some seedlings, but no known mortality was caused by grazing. Porcupine damage continued so that after four years 59 percent of surviving uncaged seedlings were killed or severely damaged, and two caged seedlings were clipped and girdled. This reforestation effort was a failure despite the costly practices of planting 3-0 seedlings, site preparation, and fencing to exclude deer. Ninety percent of the caged seedlings survived without damage. An early appreciation of the

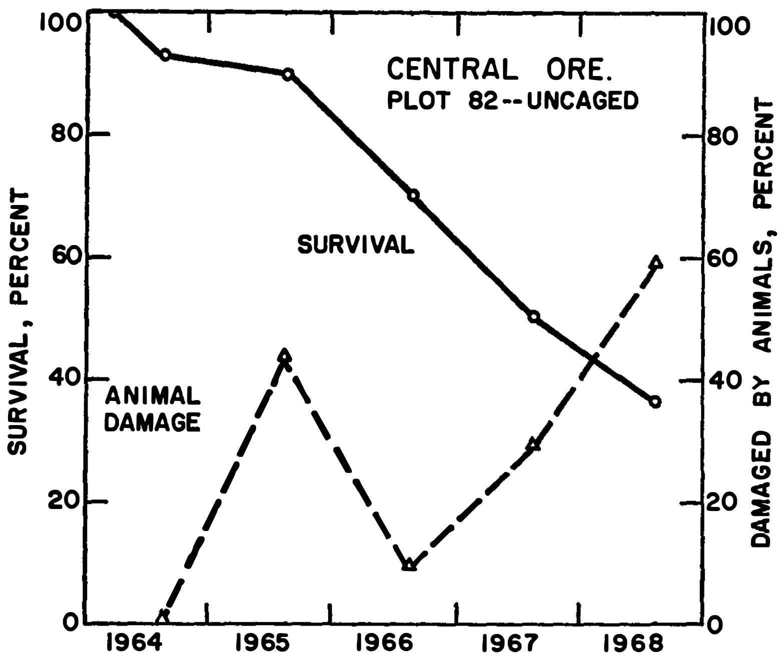


Figure 4.—Survival of uncaged ponderosa pine seedlings and occurrence of animal damage to seedlings[1] on Plot 82 in central Oregon.

[1]Percentage occurrence of animal damage is based on the number of seedlings damaged each year, divided by the number alive one year before, multiplied by 100.

potential damage that forest rodents cause might have permitted the development of more effective measures to control their damage.

Plot 32. Two-year-old, repellent-treated Douglas-fir seedlings were planted in January 1964 on plot 32 in the Coast Range of western Oregon. The plantation is on a high-quality site for Douglas-fir (Site II). The area supports a high population of black-tailed deer, which are abundant on the plantation throughout the year. Impact of browsing injury by deer on height growth is illustrated in Figure 5. Survival of seedlings on the sampling plot is excellent (100 percent of caged and 95 percent of uncaged), after four growing seasons.

Browsing injury from time of planting until bud burst was negligible, possibly because of the repellent treatment, but new shoots on most uncaged seedlings were browsed by deer following bud burst in 1964. This pattern of repeated browsing of new shoots on most seedlings, with a smaller amount of browsing of stems during the dormant period, has been repeated each year. An exception occurred in 1965, when leaders of uncaged seedlings were browsed by deer during the dormant period. The impact of repeated browsing did not affect survival, but caused significant suppression of growth (Figure 5). Indications are that suppression will continue, as new shoots on nearly all uncaged seedlings were browsed by deer in the spring of 1968. The mean height of caged seedlings at the end of the growing season in 1967 was 51.6 inches, compared with a mean height of uncaged seedlings of 11.1 inches. The growth potential (or yield) of this site is not being realized because of repeated browsing injuries. Thus, the full sustained-yield capacity of this land is reduced.

DISCUSSION

We are nearing completion of the most comprehensive survey of animal damage that has been undertaken in the region. Our findings on the occurrence of animal damage and on the true impact of this damage in reducing forest productivity will be valuable to forest and wildlife managers in the region. But as Crouch cautioned (1968), we must translate these findings into workable guidelines that foresters can use to realistically manage the problems they encounter in the field. Further analyses of the data are planned to examine possible inter-relations among animal damage and site factors. Continued examination of selected plots is also planned to provide a better estimate of long-term effects of animal damage.

Based on a recent questionnaire survey of animal damage on national forests in Oregon and Washington, Crouch (1969) reported that foliage browsing was the most common type of injury, followed by barking, root clipping, foliage clipping, and trampling. Problem

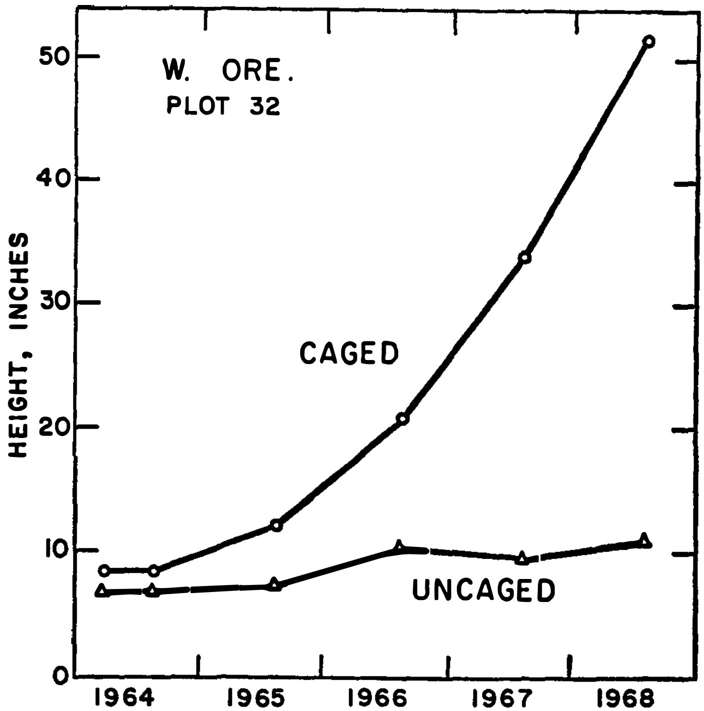


Figure 5—Mean height of caged and uncaged Douglas-fir seedlings on Plot 32 in western Oregon.

animals, rated by frequency of citation, were deer, porcupines, pocket gophers, hares and rabbits, elk, livestock, small rodents, mountain beavers, and bears. The Forest Service also estimated that about 25 percent of all reforestation work must be redone; animal damage accounted for 20 percent of all reasons cited for necessary replanting on areas where reforestation measures had failed.

Weyerhaeuser Company, in a recent rating of losses caused by forest wildlife on their lands,[7] assigned 44 percent of damage causes to deer and elk, 35 percent to rodents, 13 percent to bears, and 8 percent to porcupines and livestock.

In a current review of the status of problems caused by five groups of small mammals in Oregon and Washington, Canutt (1968) ranked, in order of importance, porcupines, pocket gophers, hares and rabbit, mountain beavers, and dusky-footed woodrats.

Estimates by forest managers of animal damage on public and

[7]Morgan, H. E. 1967. Forests, fauna, and finances. Speech, Pacific Logging Congress, November 9, 1967. 12 p. Weyerhaeuser Company files.

private forestlands in Oregon and Washington were also reviewed by Dimock and Black (1968). The predominant damage reported was foliage browsing by deer, but the estimates underscored the regional diversity in nature and relative importance of different types of animal damage as seen by forest managers. Much of the difference in emphasis accorded each group of forest wildlife by these surveys is caused by the inclusion in the estimates of all age classes from regeneration to mature stands. Nontheless, as demonstrated by this survey, foliage browsing by deer greatly exceeds all other types of animal damage. Deer were also reported as the primary cause of damage on forests in California (Calif. Pest Action Council, 1964).

Our findings demonstrate that animal damage occurs generally throughout the region, varies in nature and degree, and probably has a significant impact on productivity. Clearly, the risk of damage requires added costs for control measures such as repellents, large planting stock, mechanical barriers, and site preparation. Replanting and other costly retreatment also may be required, or reduction of stocking to a low level may reduce future yields.

The large amount of seedling mortality unrelated to animal damage, especially that recorded soon after planting, is singularly significant. It is of added importance in assessing the occurrence and extent of animal damage, because of the common tendency of some resource managers in the region to assume that animals cause most tree losses. This assumption arises because reforested areas are examined infrequently, usually only on the first and third years after planting, and most dead seedlings go undetected, but surviving trees often evidence animal damage and the animals or their sign are ever present.

Animal-caused mortality of trees, particularly the continued attrition over several years that typifies damage caused by mountain beavers, pocket gophers, and porcupines, combined with high natural mortality, particularly on "tough sites," may assume added importance in the long run. Conversely, minor mortality associated with animals may not affect stocking significantly. A recent study by Grah (1960) suggests that animal damage in the form of a reduction in initial stocking of Douglas-fir is negligible so long as stocking remains at about 300 trees per acre. But below this level, Grah found that damage is probably related linearly to stocking level. Teeguarden (1968) estimated the difference in present value of a Douglas-fir plantation with about 75 trees per acre in comparison to one with 600 trees per acre to be on the order of \$130 per acre for Site II, \$71 per acre for Site III, and \$34 per acre for Site IV.

Animal-caused suppression of height growth is the most common and wide-spread effect of animal damage in the region. But as Crouch

(1968) noted, we know very little about the long-term effects of damage that suppresses growth. Relations between trees browsed as seedlings and their appearance and condition at rotation age have not been described.

Suppression of growth suggests potential extension of rotation. Smith and Walters (1965) calculated that an advantage of 10 inches in height between Douglas-fir seedlings when planted could be associated with a difference of 2.6 years in length of the rotation, if the advantage persists. They also asserted that each year by which rotation length can be shortened has a substantial present worth. However, in a study on Vancouver Island to determine the effect of animal feeding upon height growth in Douglas-fir plantations, Mitchell (1964) concluded that productivity likely would not be seriously affected at rotation age, despite an average reduction in tree height caused by deer browsing of from one-half to 2 feet over a period of 8 to 10 years.

A recently completed assessment of the impact of animal damage on tree farms of the Weyerhaeuser Company in the Pacific Northwest showed that 224,000 acres (or 8 percent) of the Company's lands are affected by animal damage. As a consequence, the average loss in yield of damaged areas was estimated as 6,000 board feet per acre. This is equivalent to a total reduction in yield of 1⅓ billion board feet.

Dimock and Black (1968) concluded that within the Pacific Northwest, damage by animals is costing the timber industry several million dollars each year. However, they pointed out that many variables, projections, and assumptions are involved in damage assessment. Flora (1968) gives an excellent insight into this common problem. He emphasized the potential pitfalls in appraisals of economic damage that are sometimes ignored in hasty studies. Thus, the true impact of animal damage in the long run can only be assessed in combination with all site factors that affect tree growth, and with related economic analyses.

SUMMARY

A survey of animal damage to forest plantations in Oregon and Washington was begun in 1963, under the direction of the Cooperative Animal Damage Survey Committee. The survey is scheduled to end in 1969. Cooperators in the two states installed a series of 112 randomly located sampling plots in plantations during 1963-64 and a second series of 82 during 1964-65. Of these plots, 165 are on Douglas-fir plantations, 4 are in mixed Douglas-fir and ponderosa pine, and 25 are in ponderosa pine and Jeffrey pine, or mixtures of the two. Three-

quarters of all plots are in Oregon, and most of the plots in both states are on public lands.

We found a significant amount of mortality, unrelated to animal damage, soon after planting. Several sampled plantations were complete failures, and others have suffered heavy mortality (from all causes). After four growing seasons, survival of uncaged seedlings in the first series of plots averaged 60 percent for Douglas-fir and 52 percent for pines. Average survival of uncaged seedlings in the second series after only three growing seasons was similar for Douglas-fir (58 percent), but higher for pines (56 percent). Based on differences between survival of caged and uncaged seedlings, animals caused 35 percent of the mortality in Douglas-fir, 51 percent in the pines.

As determined by annual examinations, animals damaged seedlings on all plots. Browsing and clipping of stems were the principal causes of seedling injury. Cutting of roots, budding, barking, trampling, pulling seedlings from the ground, and covering seedlings with soil also were noted. Browsing by deer was the most common source of animal damage on all plots. Animals that injured seedlings, ranked by frequency of damage in 1968, were big game, hares and rabbits, grouse, mountain beavers, pocket gophers, domestic stock, porcupines, microtine rodents, and moles.

Animal damage markedly reduced the height growth of unprotected seedlings. After 4 years, the mean height of uncaged Douglas-fir trees in the first series in Oregon and Washington was 23.4 inches, compared with mean height for caged seedlings of 33.1 inches.

ACKNOWLEDGMENTS

The Committee acknowledges the work of Francis R. Herman, Robert B. Pope, and Floyd A. Johnson of the Pacific Northwest Forest and Range Experiment Station in preparing the preliminary plans for the inventory of animal damage.

The cooperating industrial forestry companies and public land management agencies installed the sampling plots, made the initial measurements of tree heights, and gave other assistance. The CADS Committee, with William Looney of Simpson Timber Company, Washington, as Chairman, assisted with planning and coordination of the survey. Edward F. Hooven and Richard P. Newman, Oregon State University; Donald Swanson, Weyerhaeuser Company; Dan L. Campbell, Bureau of Sport Fisheries and Wildlife, Olympia; Dr. Glenn L. Crouch, Pacific Northwest Forest and Range Experiment Station, Olympia; Harry Hartwell, Washington State Department of Natural Resources, Olympia; and others helped with field examinations and transcription of data. Louella Spencer, Weyerhaeuser

Company, Kenneth Wilmarth, Colorado State University, Dr. Charles Loveless and John Oldermeyer assisted with programming and analysis of data.

LITERATURE CITED

California Pest Action Council.
1964. Animal damage survey—1962. California Pest Control Action Council Report. 14 p. mimeo.

Canutt Paul R.
1968. Status of certain animal damage problems in Washington and Oregon. *IN, Proceedings,* Symposium on Wildlife and Reforestation in the Pacific Northwest. School of Forestry, Oregon State University, Corvallis. 1969.

Crouch, Glenn L.
1968. Deer-reforestation relationships in the Pacific Northwest. *IN, Proceedings,* Symposium on Wildlife and Reforestation in the Pacific Northwest. School of Forestry, Oregon State University, Corvallis. 1969.

——————.
1969. Animal damage to conifers on national forests in the Pacific Northwest. Pacific Northwest Forest and Range Experiment Station, For. Service, U.S. Dept. of Agric. 28 p. (in press)

Dimock, E. J. II, and H. C. Black.
1968. Scope and economic aspects of animal damage in California, Oregon and Washington. *IN, Proceedings,* Symposium on Wildlife and Reforestation in the Pacific Northwest. School of Forestry, Oregon State University, Corvallis. 1969.

Flora, Donald F.
1968. POOH on damage appraisal. J. Forestry 66:12-16.

Grah, Rudolf F.
1960. Effects of initial stocking on financial return from young-growth Douglas-fir. Hilgardia 29(14):613-679. Univ. of Calif., Berkeley.

Harper, James A.
1968. Relation of elk reforestation in the Pacific Northwest, *In* Proceedings Symposium on Wildlife and Reforestation in the Pacific Northwest School of Forestry, Oregon State Univ., Corvallis, Oregon, 1969.

Herman, F. B., R. B. Pope, and F. A. Johnson.
1963. Plan for inventorying of animal damage to forest plantations in the Pacific Northwest. PNW Forest & Range Exp. Sta. 19 pp.

Hermann, Richard K.
1968. Review of animal damage problems and their relation to reforestation practices. *IN, Proceedings,* Symposium on Wildlife and Reforestation in the Pacific Northwest. School of Forestry, Oregon State University, Corvallis. 1969.

Lawrence, W. H.
1958. Wildlife-damage control problems on Pacific Northwest Tree Farms. 23rd N. Amer. Wildl. Conf. Trans. p. 146-151.

——————, N. B. Kverno, and H. D. Hartwell.
1961. Guide to wildlife feeding injuries on conifers in the Pacific Northwest. Western Forestry and Conservation Assn. 44 p.

Mitchell, K. J.
1964. Height growth losses due to animal feeding in Douglas-fir plantations, Vancouver Island, British Columbia. Forest Chron. 40:298-307.

Moore, A. W.
1940. Wildlife animal damage to seed and seedlings on cut-over Douglas-fir lands of Oregon and Washington. U.S. Dept. of Agric., Tech. Bul. 706. 28 p

Oregon State Game Commission and Oregon State Board of Forestry, Cooperating.
1968. Trees and deer, a progress report on the Cedar Creek deer study. Oregon State Game Commission, Portland. 14 p.

Payne, Brian R.
1964. Trends in reforestation and its cost in the Pacific Northwest. Pacific N.W. Forest and Range Expt. Sta., Forest Service, Dept. of Agric. Misc. Publ. 11 p.

Smith, J. Harry G. and John Walters
1965. Influence of seedlings size on growth, survival, and cost of growing Douglas-fir. Univ. of British Columbia, Fac. of For., Research Notes No. 50. 7 p.

Teeguarden, D. E.
1968. Economic guides for Douglas-fir reforestation in southwestern Oregon. U.S. Dept. Interior. Guides to Land Management Report. Washington, D. C. (in press)

U.S. Dept. of Agric., For. Serv.
1967. Report. Forest and wind barrier planting and seeding in the U.S. Tree Planter's Notes 18(5):7.

DISCUSSION

MR. BYELICH: Apparently animals are maintaining their own habitat by chewing it back into regrowth to provide them with a new food supply the following year. Certainly some damage can be expected, but I'm wondering what does forestry really expect from your plantation? Do you really expect 100 percent survival, and what percent of the plantation do you expect at maturity?

DR. BLACK: That's a very good question. I indicated at the outset that mere occurrence of injuries, whether it's injury that will kill seedlings, such as pulling seedlings out of the ground or clipping them off, isn't going to have much impact. Browsing injury which may cause suppression of growth but which affects only a small percentage of the seedlings, also, won't have much impact.

What we're concerned with is damage of sufficient magnitude that either survival is so poor that we have to restock the plantation and probably have lost several years of growth in the meantime, or we will accept this reduced stocking and a reduced yield at the end of rotation.

On the other hand, if injury is sufficiently extensive and persists, we can have suppression of growth and an extension of the number of years required for the trees to gain maturity.

MR. E. V. KOMAREK (Florida): I noticed that practically all of your plots were on burned land. This might create a fallacy in some of your results if the land around these areas is managed differently. We know that vegetation that comes up on burned land is higher in protein and so you are literally trapping the animals on your plantation. If so, this is rather unusual damage except as it applies to these kinds of conditions.

DR. BLACK: I don't wish to imply that we're simply sampling reforestation on wildfire areas; this is not the case.

We have a random sampling of all of the plantations, all of the reforestations in the Douglas-fir and the ponderosa pine region of the two states in the two years.

If wildfire areas were reforested, we were on those areas, but in the main, we were on areas on which the timber was cut and the slash was burned. It's quite different than a wildfire situation. On most of the cut over areas, the slash is burned.

FROM THE FLOOR: You indicated that apparently half of the artificial regeneration was direct seeding and the other was planting. Do you find any difference in the degree of damage to plantings versus direct seedings?

DR. BLACK: Well, I expect there was, but we were only concerned with plantations where seedlings were planted. We did not sample areas that were seeded artificially and we did not sample natural regeneration, but as to damage occurring on seeded areas, we have very serious impact by animals—particularly small animals and birds—on the seed itself and then on the newly germinated seed. We have not attempted to study any differences quantitatively.

FROM THE FLOOR: In the South we have a similar problem, not near the magnitude that you have, but where we plant pine seedlings, we get damage from animals we never get in natural regeneration or even with direct seeding. We think fertilization in the nursery is the possible cause of this.

MR. W. H. LAWRENCE: (Weyerhaeuser Co., Washington): You were interested in the impact of these losses on a forest and you answered it in a rather general way. I would like to be a little more specific and say that now in a program of intensive management in the Douglas-fir region we are developing some tables of performance which will establish stocking standards, that is the space between trees, which will give us the number of trees per acre and also a growth curve schedule that tree seedlings will have to meet in their growth performance. So we can tell at four and a half feet whether a tree is on schedule or not by the number of years it has taken to reach that point.

So forestry is becoming an extremely intensified practice. We're developing rather precise standards for judging performance and these case histories will give us an opportunity to build into our computer simulation and allow for animal damage. The real value of the survey in providing some precise information on what kinds of losses we can expect on forest sites. We have a lot of estimates and horseback guesses, but this is the first time that we will have precise case history information for this intensive type management.

THE MOUNTAIN GOAT IN COLORADO[1]

DALE HIBBS[2]
Colorado Game, Fish and Parks Division, Denver;
FRED A. GLOVER[3]
Cooperative Wildlife Research Unit, Fort Collins, Colorado; and
DOUGLAS L. GILBERT[4]
Colorado State University, Fort Collins, Colorado

The mountain goat (*Oreamnos americanus*) is one of many big game animals that have been able to withstand the tremendous early exploitation imposed by the westward movement of civilization. In the past, the population of mountain goats in the United States appears to have been stable with the exception of introduced herds. However, wildlife resources in the West are now being subjected to additional pressures of an increasing human population with more time for recreational hunting. To meet this challenge, wildlife managers will have to intensify their efforts and utilize the best techniques and information available.

Although not native to Colorado, the mountain goat has become successfully introduced on some of Colorado's higher mountains. A current estimate of the number of goats in Colorado is 350. The information presented here is the result of an intensive two-year study (1963 and 1964) of the ecology of the mountain goat in Colorado combined with additional studies during 1965 and 1966. Over 1600 hours were devoted to field study during which more than 5000 observations were made of mountain goats. The project was supervised by the Colorado Cooperative Wildlife Research Unit and financed through the Colorado Game, Fish and Parks Division Federal Aid to Wildlife project W-41-R-14.

The Collegiate Range, located in south central Colorado, was the main area studied since approximately 85 percent of Colorado's mountain goats occur here (Fig. 1). However, additional data were obtained from the Mt. Evans area, approximately 50 miles west of Denver, where approximately 75 mountain goats live. At the present time, there are from 250 to 300 goats in the Collegiate Range, a substantial increase from the original 14 released in the area in 1949. A third herd of less than ten is found in the Gore Range, and a 1964 transplant of six animals is maintaining itself in the San Juan Mountains.

---

[1]Contribution of the Colorado Cooperative Wildlife Research Unit; Colorado State University; Colorado Game, Fish and Parks Division; Wildlife Management Institute; Bureau of Sport Fisheries and Wildlife, cooperating.
[2]Assistant Wildlife Researcher, deceased.
[3]Biologist, BSF&W, and Leader, Cooperative Wildlife Research Unit.
[4]Professor, Department of Fishery and Wildlife Biology.

A base camp was established in the Collegiate Range at 10,500 feet elevation at Mt. Shavano. Daily trips were made to goat habitat less than one mile away. The effects of weather, elevation, aspect, topography, slope, and vegetation type as related to mountain goat activities were recorded. Sex of goats was determined whenever possible, using urination posture as the determining criterion. Simply, the male stretches and the female squats. This technique proved to be satisfactory for distances to one mile when a 30X spotting scope was used. The technique was applicable to kids as well as adults. Aerial flights were conducted each month to get gross information on distribution and habitat use. During the flights mountain goats were seen in areas ranging from approximately 9,500 feet to 13,500 feet elevation, with the greater number (61%) being observed in the 12,000-13,000 foot zone. Similar results were obtained from ground observations, except that a greater number (81%) were in the 13,000 to 14,000 foot zone.

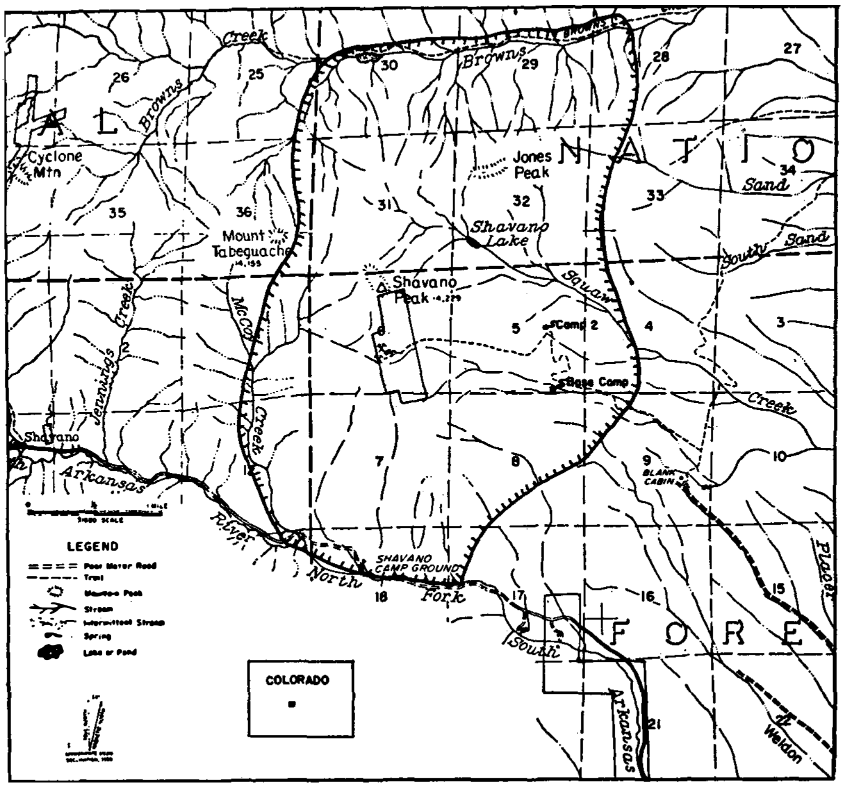


Figure 1.—The intensive study area on Mt. Shavano, Collegiate Range, Colorado.

Mountain goats were recorded throughout the year at various elevations. The season of the year apparently had little effect on which elevation they utilized. Mountain goats in the Collegiate Range occupy some of the highest elevations, as well as the southernmost location of any mountain goat population in North America.

Mountain goats in the Collegiate Range appeared to have a higher reproductive rate and lower mortality rate than those studied in Idaho and Montana (Brandborg, 1955). The highest reported production rate we found in the literature was by Hanson (1950), who reported a kid:yearling:nanny ratio of 86:52:100 in the Black Hills of South Dakota. Other studies on mountain goats (Anderson, 1940; Cowan, 1944; and Brandborg, 1950 and 1955) have shown kid:yearling: nanny ratios varying from 33:7:100 to 75:55:100.

We studied the Mt. Shavano herd intensively in the Collegiate Range. During 1963, the kid:yearling:nanny ratio was 150:25:100, indicating that a substantial number of nannies had twins. In 1964 the ratio was 100:125:100. Although only aerial observation information was obtained on other herds of mountain goats in the Collegiate Range and on Mt. Evans, similar high reproductive rates were indicated. We believed the high reproductive rate of the Mt. Shavano herd could be attributed in part to the fact that all the adult females were concentrated into two large herds, making it highly improbable that any adult female would not be bred. Also, kid and yearling survival were good. Most investigators (Anderson, 1940; Hanson, 1950; and Brandborg, 1955) have found that seldom will more than 50 percent of the kids live through the long-yearling age class.

From the 5,039 observations of mountain goats, it was found that 86 percent were associated with southern exposures. We attributed this preference to the fact that south-facing exposures in the Rocky Mountains typically have more moderate microclimates than other aspects. Here vegetation is abundant and although soil surface temperatures may reach 100°F the solar heating is moderated by cool winds.

Daily movements of mountain goats were related primarily to two basic activities: feeding and bedding. Data on these activities were recorded as distance moved in yards when feeding and traveling to resting places. Mountain goats generally dispersed in different directions when feeding and then regrouped later to travel to a common bedding ground. To determine the mean daily movement during summer (June—September), only those days were used when the goats were under continuous observation for 12 or more hours. From these data it was found that the mean daily movement was 691 yards with a standard error of 82 yards. During summer rainstorms mountain goats remained relatively inactive. After a storm passed, the goats commenced to feed, and this was one of the best times to observe them. When one considers the vast expanse of suitable summer habitat available, the mean daily movement of approximately 700 yards seems quite limited. In winter, when deep snows hinder movement, mountain goats might be confined to small areas for several weeks at a time.

During summer months mountain goats generally left their bedding ground shortly after daylight (about 5:00 a.m.), started feeding, and fed intermittently until mid-morning (10:00 a.m.). The morning feeding was found to be the longest of the feeding periods although mountain goats were observed to feed during all daylight hours for continuous periods from 10 minutes to 2 hours and 15 minutes. During most summer days mountain goats tended to feed gradually uphill in the morning and into early afternoon (1:00 p.m.). In late afternoon (4:00 p.m.) and evening they fed downhill, drifting toward the base of the valley. This daily movement uphill during the hot part of the day may have been an effort by the goats to seek cooler elevations as well as areas of greater air circulation and possibly to escape from insects. The goats appeared to follow a grazing pattern in which they tended to move freely between five different basins, usually during late afternoon and evening. Under these circumstances the goats would feed throughout the next day in the immediate area until late afternoon and then start traveling again. This same procedure was repeated until the goats reached their desired destination. They then would settle down and remain in a small area of 5 to 6 acres for 3 to 7 days before moving on. Goats in the Collegiate Range did not exhibit true migration. Instead, they moved freely throughout the range and did not use particular areas during any one season. Observations in Alaska, Idaho and Washington showed that seasonal migrations occurred between winter and summer ranges (Anderson, 1940; Brandborg, 1955; and Klein, 1953).

Analysis of field data indicated that a significant statistical difference (95% level) existed between the length of time spent feeding during four selected time periods of each day. It was clear the goats spent more time feeding during time intervals I (6:00–9:00 a.m., $\bar{x} = 63$ min.) and IV (3:01–6:00 p.m., $\bar{x} = 61$ min.) than during intervals II (9:00 a.m.–12 noon, $\bar{x} = 41$ min.) and III (12:01 p.m.–3:00 p.m., $\bar{x} = 43$ min.). Thus, a daily feeding pattern of two active periods, morning and evening, were separated by minor feeding during the middle of the day. No significant difference occurred, however, between Time Intervals II and III, and I and IV.

In general, mountain goats preferred to live in close groups—

bedding, feeding, and traveling together. Females left the main herd to have their young in the spring, but they rejoined the main herd when the kids were able to follow. During spring and summer the males were solitary or in small groups. In the breeding season males joined the females, kids, and yearlings. Following the rut, the herds reached their greatest numbers. A decline in herd numbers occurred during winter and early spring. Although mountain goats tended to band together, the adults in a herd appeared to be intolerant of each other.

Probably the most intolerant animals in a herd were the adult nannies with kids. Normally, agonistic behavior was displayed by adult females when other members of the herd approached to within a minimum tolerance distance of approximately 10 feet. Adult females also exhibited similar behavior when their kids were approached by other members of the herd. No physical contact was observed during these displays, which typically resulted in nothing more than a short rush-threat with a horn-thrust by the attacking female. The intruder retreated in all cases observed. Geist (1964), however, cited an example where two adult males inflicted serious wounds on each other during the rut. Most encounters, however, appeared to be settled by a few fast rushes, followed by the hasty retreat of one participant.

A particular goat did not serve as leader of the herd; however, the older adult females with young appeared to demand the greatest respect from the other age groups. The "peck order" within the herd in decreasing scale of respect was: females with young, females without young, two-year-olds, yearlings, kids, and adult males. From observations of the intra-herd relationships within the various sex and age classes, it would be our recommendation that transplants for stocking new ranges include at least the following composition: three adult females; two adult males; two, 2-year old females; one, 2-year old male, and if possible, four yearlings with an even division of the sexes. When transplanting goats into new areas, they should be kept in holding pens in the vicinity of the transplant site and released as a group rather than individually. If possible, the animals should be held in the pens until they have become familiar with their new surroundings and have become quiet. These precautions will help eliminate the wide scattering and eventual loss of individuals seeking their native range.

The mountain goat is considered to be a tolerant animal and seldom displayed antagonism toward other big game species. Brandborg (1955) noted occasional intolerance between mountain goats, elk, and deer at salt licks. Klein (1953) reported intolerance between mountain goats and bighorn sheep. We found the mountain goats to be indifferent to the presence of bighorn sheep, but at times the sheep appeared annoyed and would leave an area occupied by mountain goats. Competition for food and cover between mountain goats and other big game species on mountain goat habitat in Colorado is considered slight during most of the year. However, competition was noted during critical winter periods when sheep and goats occasionally became concentrated on lower elevation ranges in the winter. The influence of livestock grazing to mountain goats was regarded as minimal due to the rugged type of terrain occupied by the mountain goats.

Another phase of this study was concerned with the food habits of mountain goats. Investigations in other areas have shown the seasonal food preferences of mountain goats to be extremely variable. These conclusions were substantiated by this investigation. Anderson (1940) found that goats in Washington browsed more than they grazed during the summer. When bunch-grasses were available on the winter range, they made up as much as 90 percent of the diet. Cowan (1944) found that five goat stomachs collected during the summer in British Columbia contained 63 percent grasses and sedges, 23 percent willow, and 14 percent herbaceous vegetation. Grasses and sedges made up the greater amount of the mountain goat's diet in Alaska, according to Klein (1953). He reported that browsing was done mostly in winter, but even then woody plants comprised only a small percentage of the diet. Brandborg (1955) analyzed the contents of six goat stomachs collected in Montana and found that grasses and mountain mahogany provided 96 percent of the volume of winter foods. Shrubs were considered primary and grasses and forbs secondary in the summer diet of goats in Montana (Casebeer, 1948). Grasses made up about 65 percent of the winter forage in Montana with shrubs of secondary importance. Many browse species, heavily used in summer, were not browsed in winter.

To obtain information on food habits, stomach samples were analyzed from four goats killed during the regular 1964 mountain goat hunting season. In addition, Forest Service standard, "Parker 3-step" utilization transects were conducted in areas where mountain goats had fed. Similar results were obtained from those two methods indicating that grasses and grass-like plants made up the bulk of the summer diet. The stomach samples contained an average of 89 percent grasses and grass-like plants while transect data showed that Kobresia (*Kobresia bellardi*), Scribner's wheatgrass (*Agropyron scribneri*), and bluegrass (*Poa* sp.) were the species utilized most on the summer range.

Grasses and grass-like plants also constituted the bulk of the winter diet; although, moderate browsing of woody plants occurred. Mountain muhly (*Muhlenbergia montana*), Arizona fescue (*Festuca arizonica*), and Thurber's fescue (*Festuca thurberi*) were the species showing greatest utilization on the winter range. Limited winter use was made of Rocky Mountain maple (*Acer glabrum*), Mountain mahogany (*Cercocarpus montana*), squaw currant (*Ribes cereum*) and willow (*Salix* sp.).

Dominant plants in the areas of heaviest goat use were alpine clover (*Trifolium dasyphyllum*), dwarf clover (*Trifolium nanum*), Kobresia, and alpine avens (*Geum turbanatum*), with an average of 17.0 hits per transect for the clovers, and 15.5 and 11.0 for Kobresia and alpine avens, respectively. The plant density index of these areas averaged 64 hits per transect, with an average of 43.7 hits per transect on desirable and intermediate plants. It appeared these areas were preferred by goats as evidenced by frequent and repeated use.

Although water may not be an important factor, it probably influenced distribution of certain mountain goat herds. This was evidenced from the data on movements which showed that goats seldom were found more than one-half mile from free water. Goats were observed eating snow as well as drinking from free water sources on numerous occasions during the study. They also exhibited stress during periods of drouth.

Probably the most salient feature of mountain goat habitat in Colorado was the rugged topography these animals occupied. Nearly all areas where goats were observed were characterized by sheer rock outcroppings and talus slides interspersed with steep grassy slopes. Goats in Colorado utilized this intermittent rock-grass type 70 percent of the time and seldom were observed far from cliffs and large rocks. Swift (1940) similarly noted that during inclement weather, heat of day, and when kidding, mountain goats in the Black Hills of South Dakota also sought shelter in caves, under overhanging rock ledges and among large rocks and boulders.

Another habitat requirement of importance to mountain goats in Colorado was the availability of rough, precipitous terrain on low (9,500 to 10,000 feet elevation) southern exposures. Topography of this type was used by nannies as kidding grounds during spring. These areas also were used as wintering grounds during periods when deep snow covered the grasses above timberline.

The high-elevation, exposed, windswept, alpine terrain above timberline was an important part of the mountain goat's habitat in Colorado. Mountain goats were observed using these areas during all months of the year and the accessibility, availability, extent, and juxtaposition of habitats of this type might well be the limiting factor during critical winter periods when deep snow limits the mobility of the goats and covers major grassland feeding areas. Aerial surveys of utilized or potential mountain goat habitat during winter months provided an evaluation of the importance of such terrain to the mountain goat.

Censusing from the air proved to be the best method of determining the number of goats occupying a broad area in the Collegiate Range. Data from air and ground counts on the same areas compared quite closely. It was found that individuals could be counted accurately on the film of an aerial photograph of a herd, and this was one of the best ways to obtain a count when the goats were in open areas above timberline.

Population status can be determined easiest and most economically by periodic aerial censuses. Based on experience gained in this study, the slow flying, maneuverable Piper Super Cub (PA-18 with 140 HP engine) proved to be very good. The helicopter was best for censusing; however, the cost per hour was about six times greater than the Super Cub ($15.00 compared to $90.00). Early morning and late evening seemed best for census work since most of the mountain goats were feeding and consequently were more visible than at other times during the day. The best time to obtain a total count of goats in an area was during the last two weeks of November. Aerial counts on two successive days seemed to provide more reliable information.

Colorado has had a mountain goat season since 1964. We believe this is in keeping with the object of providing high-quality recreation, even if only for a few hardy hunters. To be legal, the animal must have horns six inches long or longer and not be followed by a kid. Theoretically, this selects the males. With a polygamous species, such as the goat, this does not hurt the breeding potential. Four goats were killed in the Collegiate Range in 1964, 4 in 1965, and 3 in 1966. In 1967 the Mount Evans area also was opened to hunting. One hundred twenty-seven people applied for 18 permits and 14 goats were killed (77%). In 1968, 154 people applied for 19 permits and killed 15 goats (79%).

If an individual draws a permit one year, he cannot apply the next. Some have suggested that if a person kills a mountain goat in Colorado, he should not be allowed to apply again for five years. This, however, is not yet part of the current regulations. Non-residents are not permitted to hunt mountain goats in Colorado.

Continued close management will be necessary to maintain established herds. It is evident that as each year of hunting passes, Colorado sportsmen become more interested in the mountain goat. Under the impetus of increased enthusiasm, it is important not to liberalize the number of annual permits beyond what the resource can stand. For this reason, close surveillance of present herds for continued maintenance of their numbers will be necessary.

In areas where mountain goats have increased, we feel it is a good management practice to trap surplus goats and introduce them into new areas. Montana and Alaska have been successful in establishing mountain goats with this method. It is our belief that Colorado has considerable potential for increasing the number of mountain goats.

At present, mountain goats can be trapped from herds in the Collegiate Range for transplantation to other suitable areas. First, however, location of suitable sites will need to be made. A general feasibility survey should be conducted by airplane during late winter (February, March and April) since this period appears to be the most critical. Relative evaluation of prospective transplant sites should be on the basis of presence and extent of wind-swept, snow-free terrain with southern exposures in juxtaposition to protective cover such as rocks, ledges, caves and brushy patches. An indication of carrying capacity for the prospective transplant sites can be made using a daily food consumption factor of 3 lbs. (air-dry weight) per animal, per day. The food consumption factor was derived from research on deer (Carhart, 1946; Cowan, et al., 1957; and Nichols, 1938) but we feel it would be usable for mountain goat range evaluation.

Livetrapping mountain goats is difficult because of the rough terrain in which they live. A variety of traps has been used, but the pen-type trap used in Montana for trapping goats and in Colorado for bighorn sheep, may be the most successful. The main disadvantages of this trap are its large size and high cost of construction. The Clover trap also has been used successfully. It is collapsible and is automatic, but captures only one goat at a time. The light weight of this trap and its size make it useful for back-country trapping. Trapping and transplants should be made in the summer.

General management plans should be made for each herd that becomes established, considering both quantity and quality in arriving at the desired harvest. Limited harvest by hunters under a permit system could remove surplus adult males during early stages of herd build-up with a gradual increase in permits as herd numbers justify removal. Productive females should be protected, and this is not entirely being done with present regulations. However, there is a problem of making the regulations more restrictive and placing an undue burden upon the hunter.

We acknowledge the willing help given on this project by William Rutherford, William Jones, and Richard Denney, all research biologists with the Colorado Game, Fish and Parks Division.

LITERATURE CITED

Anderson, N. W.
1940. Mountain goat study. Wash. Dept. of Game Biol. Bull. 21 pp.

Brandborg, S. M.
1950. The life history and ecology of the mountain goat in Idaho and Montana. M.S. Thesis Univ. of Idaho, Moscow. 115 pp.

Brandborg, S. M.
1955. Life history and ecology of the mountain goat in Idaho. Proj. Completion Rept., P-R Proj. 98-R. Ida. Fish and Game Dept. Bull. 2. 142 pp. Thesis, Univ. of Idaho, Moscow. 115 p.

Carhart, A. H.
1946. Hunting North American deer. The Macmillan Co., New York, N. Y. 232 pp.

Casebeer, R. L.
1948. A study of the food habits of the mountain goat (*Oreamnos americanus missoulae*) in western Montana, M.S. Thesis. Montana State University, Missoula. 84 p.

Cowan, I. McT., A. J. Wood, and W. D. Kitts
1957. Feed requirements of deer, beaver, bear and mink for growth and maintenance. N. Amer. Wildl. Conf. Trans. 22:179-188.

Geist, V.
1964. On the rutting behavior of the mountain goat. J. Mammal. 45:551-568.

Hanson, W. O.
1950. The mountain goat in South Dakota. Ph.D. Thesis, Univ. of Michigan, Ann Arbor.

Klein, D. R.
1953. A reconnaissance study of the mountain goat in Alaska. M.S. Thesis. Univ. of Alaska. 121 p.

Nichols, A. A.
1938. Experimental feeding of deer. Ariz. Agr. Exper. Stn. Tech. Bul. 75. 39 pp.

Swift, L. W.
1949. Rocky Mountain goats in the Black Hills of South Dakota. Trans. N. Amer. Wildl. Conf. 5:441-443.

DISCUSSION

MR. DAVID A. ARNOLD (Michigan): Approximately how many permits did you issue?

DR. GILBERT: In 1967, 127 people applied for 18 permits, and 14 goats were killed: 77 percent. In 1968, 154 people applied for 19 permits and 15 goats were killed in the entire state. So you see, we do restrict the numbers greatly.

MR. ARNOLD: How much do you charge for permits?

DR. GILBERT: The permits are only available to residents and they cost $40.

MR. GEORGE D. DAVIS (New York): Dr. Gilbert, do you find the mountain goat more compatible with domestic sheep in the Alpine Zone than the bighorn?

DR. GILBERT: The mountain goat is probably less compatible with domestic sheep than with the bighorn. There is a possibility of competition between the three species, especially during the summer months, but neither the mountain goat nor the bighorn sheep is particularly tolerant of domestic sheep at that high elevation.

PRESCRIBED BURNING FOR WILDLIFE—A PANEL

PRELIMINARY REMARKS

CHARLES T. CUSHWA

I would like to request that the southeastern section of this panel discussion be dedicated to the man who was instrumental in starting the prescribed burning program in the Southeast back in 1931 when he published his book, *The Bobwhite Quail*: Mr. Herbert L. Stoddard.

Unfortunately, Mr. Stoddard was unable to be with us today, but I'm sure that he is quite pleased to see a discussion such as this included in the agenda of our conference.

It is quite an honor to have been selected to present to this distinguished group some information on the use of prescribed burning in wildlife habitat management in southeastern United States.

THE STATUS OF PRESCRIBED BURNING FOR WILDLIFE MANAGEMENT IN THE SOUTHEAST

CHARLES T. CUSHWA[1]
North Central Forest Experiment Station, U. S. Forest Service, St. Paul, Minnesota; and
ROBERT E. MARTIN[2]
Virginia Polytechnic Institute, Blacksburg, Virginia

Our review of the status of prescribed burning for wildlife management in the Southeast revealed a lack of information on the specific effects of prescribed fire on wildlife habitat and populations. Therefore we divided the paper into two parts: In the first we have briefly described the area and summarized the information available on the effects of fire on wildlife. In the second part we have summarized some basic information on the technical aspects of fire[3] that may prove useful to managers and researchers in preparing prescriptions, and in understanding *why* plant and animal responses to fire vary.

The southeastern United States encompasses a land area of approximately 155 million acres, including the states of Virginia, North Carolina, South Carolina, Georgia, and Florida. Of this total, there are about 125 million acres of commercial forest land, mostly in

[1]Wildlife Biologist
[2]Associate Professor, Department of Forestry and Wildlife
[3]Williams (1938) and Cushwa (1968) have compiled bibliographies on the effects of fire on forest in the United States from the early 1900's to 1966 that may be useful to wildlife managers and researchers.

private ownership. The area is extremely heterogeneous ecologically, ranging from the boreal forest in the mountains of North Carolina to the sub-tropics in south Florida. In general, however, the area may be divided into three major physiographic provinces: the Mountains, the Piedmont, and the Coastal Plain.

MOUNTAINS

The Mountains, confined to the western parts of Virginia, North Carolina, and South Carolina, and to northwest Georgia, can be subdivided into two parts: The Blue Ridge and the Ridge and Valley.

Forest wildlife species common in the Mountains include white-tailed deer (*Odocoileus virginianus* Zimm.), ruffed grouse (*Bonasa umbellus* L.), black bear (*Ursus americanus* Pallas), eastern wild turkey (*Meleagris gallopavo* L.), eastern gray squirrel (*Sciurus carolinensis* Gmelin) and to a lesser extent fox squirrel (*Sciurus niger* L.), bobcat (*Lynx rufus* Schreber), skunk (*Mephitis mephitis* Schreber), raccoon (*Procyon lotor* L.), opposum (*Didelphis marsupialis* L.), red fox (*Vulpes fulva* Desmarest), and gray fox (*Urocyon cinereoargenteus* Schreber). Numerous passerine species are also important in this area, as are raptors, other birdlife, and smaller mammals.

The practice of woodland burning in the Mountains has not been widely used; therefore, little is known about its effect on the ecology of the area. Mumaw (1965) reported a case study of the effects of a prescribed burn on the production of hardwood sprouts in the Ridge and Valley area. He found that burning substantially increased the quantity and quality of several forage plants utilized by deer.

The effects of burning on the habitat of other wildlife species commonly found in the Mountains is not known. Burning probably increases the habitat for deer, grouse, turkey, and songbirds associated with the early stages of succession that follow burning. However, to our knowleldge there are *no* studies in progress to determine the effects of prescribed burning on wildlife habitat in this province.

PIEDMONT

The Piedmont, a strip of land through the center of Virginia, North Carolina, South Carolina and Georgia, is located between the Mountains and Coastal Plain. Approximately 90 percent of the land in this province was cleared in the early 1800's, and agriculture began with cotton and corn as the main row crops. Severe erosion, decreased soil fertility, and the disastrous cotton boll weevil, soon made farming uneconomical (Czuhai and Cushwa 1968). Accordingly, much of the land was abandoned, and a good share of it has since been naturally regenerated or planted to pine. Principal wildlife species found in this province are similar to those found in the Mountains, with two exceptions: the Piedmont has fewer grouse than the Mountains but a much larger population of bobwhite quail (*Colinus virginianus* L.). Nongame wildlife species are similar to those in the Mountains.

The recurring problem of extensive soil erosion caused by abuse of the land, together with concern over the removal of "soil building" hardwood leaf material, have been key factors in limiting the use of prescribed fire in the Piedmont. Some work has been done on the effects of wildfire on vegetation in this area (Barrett and Downs 1943; Oosting 1944). Brender and Nelson (1954) found that various prescribed burning treatments did not significantly change the species composition of woody vegetation in the southern Piedmont region of Georgia, thus supporting Oosting's earlier conclusions. Cushwa *et al.* (1966) and Cushwa and Redd (1967) compared herbaceous vegetation and seed production 1 and 2 years after burning. They found more herbs and seed on burned than on unburned plots, and more seed on plots burned during the summer than during the winter. Recently, prescribed fire was used to control undesirable hardwoods in pine stands of the South Carolina Piedmont (Goebel *et al.* 1967) and the Georgia Piedmont (Brender and Cooper 1968).

Although these studies were not conducted to determine the specific effects of fire on wildlife food plants and habitat, the results do show vegetative response to burning. With knowledge of the food and cover requirements of many wildlife species, these data may be applied directly.

COASTAL PLAIN

The third physiographic province, the Coastal Plain, extends from the Piedmont to the Atlantic Ocean and is found in all five of the southeastern states. Like the Mountains, it is separated into two categories: the Upper Coastal Plain, bordering the Piedmont, and the Coastal Flatwoods, extending eastward to the Atlantic Ocean and westward to the Gulf of Mexico. Common forest wildlife species in this province are bobwhite quail, white-tailed deer, turkey, squirrel, opossum, skunk, bear, raccoon, and numerous songbirds, raptors, and small mammals.

This province is a disturbance ecosystem, with fire the major disturbance. The flora and fauna have evolved in the presence of frequent burning and are commonly referred to as "fire species." The Coastal Plain and flatwoods have been the focal point of most prescribed burning efforts. Even such early naturalists as Bartram and Lyell in their travels through the Southeast noted that fire was being used intentionally in longleaf pine stands to control understory vegetation, increase cattle forage, ard improve accessibility as early as the middle 1800's (Harper, 1962).

The first important effort to determine the relation between fire and wildlife habitat was reported by Stoddard (1931). He showed that frequent burning was necessary to maintain an adequate supply of food and cover for quail and turkey in the Flatwoods. Since 1931, many studies on the effects of burning on bobwhite quail and eastern wild turkey habitat have been conducted by the Cooperative Quail Study Association and still are underway by the Tall Timbers Research Station near Tallahassee, Florida.

In the Coastal Plain province, millions of acres of forest land are intentionally burned annually for one or more of the following reasons: (a) to reduce the wildlife hazard by fuel removal, (b) to dispose of slash and prepare seedbeds, (c) to increase the quantity and quality of native cattle forage, and (d) to improve wildlife habitat. Burning for any of these reasons usually accomplishes some of the others; for example, all burns are of some value to certain species of wildlife and for fuel reduction.

Despite the large amount of burning done in the Coastal Plain, there still exists a gap in our knowledge concerning the use and effects of fire. Studies are underway to determine the effect of burning on the quantity and quality of native forage plants that are vital to our range and wildlife resources (Hilmon and Hughes, 1965). Studies in fire physics, forest fuel, meteorology, soils, and ecology are being conducted at the Southern Forest Fire Laboratory to help us better understand and use this management tool. In addition, studies are in progress to determine the effect of heat and moisture produced during a fire on the germination of seed from important wildlife and range food plants (Martin and Cushwa, 1966).

SOME TECHNICAL ASPECTS OF FIRE

The information presented thus far on the use and effects of prescribed fire on wildlife habitat in the Southeast have resulted from studies of plant and animal responses to fire. As users of prescribed fire in your mangement programs, you are well aware that many fires do not produce the prescribed results. Also you are not able accurately to predict or prescribe the kind of fire that will result in the plant and seed responses you want. Because of this, managers and researchers have often resorted to the before-and-after approach, to determine the effect of burning on wildlife habitat. The *how* and *why* have been neglected in most cases. To help you better understand *how* and *why* you frequently get varied effects from fire, Dr. Martin has prepared the following technical discussion.

The characteristics of the fire that determine the effects on the biotic community are: (a) fire temperatures, (b) duration of temperature, and (c) transfer of heat. These factors are governed primarily by (1) fuel size, moisture content, and density;) (2) fuel arrangement (geometry) and (3) wind.[4] In understanding prescribed fire we must also be concerned with heat transfer within a body and the lethal temperature-time relationships of living tissue.

When we examine more closely the factors that affect a fire, we see that the amount and kind of fuel present in a given stand will depend on the type of vegetation, the rate of fuel production, and the rate of decomposition of these fuels by biological and physical agents. The amount of fuel present may vary widely within a stand or be relatively uniform, depending on the vegetation. In Coastal Plain pine stands with an understory vegetation of herbaceous plants, the variation in fuel quantity would probably be small, consisting mainly of pine needles and various types of grasses and forbs. However, in Coastal Plain pine stands where palmetto (*Serenos repens* Bartr. Small) and gallberry (*Ilex glabra* L. Gray) are the major understory vegetation, the variation in fuels would be much greater.

Combustion of forest fuels is a rapid oxidation process yielding large amounts of heat energy and therefore giving high temperatures (Byram 1959). This process reduces the amount of material on the forest floor and in the different vegetative strata, thus physically changing the environment. Chemical changes in the environment also occur in the lower strata due to the breakdown of compounds and release of other compounds or elements on the forest floor.

Fuel moisture affects the combustion process and temperatures produced. Although some heat is required to evaporate moisture, the major effects of fuel moisture on combustion apparently are due to dilution of flammable gasses, resulting in reduced burning rate and incomplete combuston. Indications are that this moisture may be effective as a temperature "buffer" in moist subfuels, tending to hold temperatures around 100°C until drying is nearly complete.

The combustion of fuel can be considered in three stages (Fig. 1). First, the preheating phase in which fuels are heated and dried by the advancing flame front. Second, the distillation phase in which destructive distillation of the fuels occurs, producing the flammable gasses. The flaming that we see is combustion of these gasses, producing very high temperatures. The third and final phase of combustion is the glowing and gradual consumption of charcoal.

---

[4]For further detail refer to Fons *et al.* 1960, 1962, 1963; Thomas 1963; Byram *et al.* 1966; Rothermal and Anderson 1966.

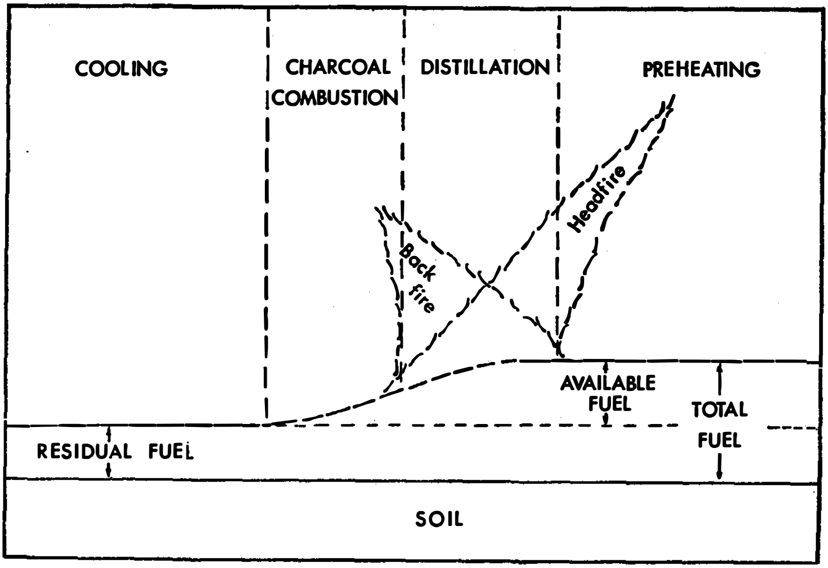


Figure 1.—Idealized sketch of the combustion of forest fuels.

Heats of combustion of some forest fuels vary from around 6,600[5] to 9,500 BTU's per pound (4400 to 5300 cal/gm). Pitch in coniferous fuel has an extremely high heat of combustion, in the neighborhood of 15,000 BTU's per pound. However, most fuels have a relatively small amount of pitch, and even our coniferous fuels generally do not have a heat of combustion over about 9,500 BTU's per pound.

Combustion of the fuels mentioned above is dependent on many factors; in general, rate of combustion (and therefore rate of spread) increases as the amount of fuel and wind in the direction of the fire increases and decreases as density, size, and moisture content of fuel particles increases. These factors interact in a complex manner to govern the temperature-time curve at a fixed point in space.

Forest fire temperature-time curves have been measured by Beaufait (1961), Davis and Martin (1960), Martin and Davis (1961), Martin (1963), Fahnestock and Hare (1964). In general, these curves indicate that fires with lower rates of spread and combustion are lower in peak temperature. However, Martin (1963, 1964) and Rothermal and Anderson (1966) have shown these variations in peak temperatures to be primarily due to heat balance within the sensing element (generally a thermocouple), rather than to differences in the rate of spread or combustion.

[5]Unpublished information from Dr. W. A. Hough, Southern Forest Fires Laboratory. U.S.D.A. Forest Service, Macon, Georgia.

Given a fire temperature-time curve, the physical effect of fire on living tissue will depend on isolation of the tissue from the high temperature region. Surface transfer coefficients, as well as thickness and thermal properties of the intervening material, will govern heating of the sensitive tissue.

As distance into a heated object from the surface increases, the temperature pulse lags further behind the external pulse (Fig. 2). Peak temperatures are also decreased, the envelope of decrease following an exponential decay curve. Studies of heat transfer into woody stems have been conducted by various workers. Martin (1963) and Herrington (1964) have conducted both theoretical and experimental studies of this nature.

Resistance of living tissue to high temperature injury at various depths within a body will determine whether or not the tissue, and possibly the organism, will survive. Studies on tolerance of living tissue to high temperatures have been conducted by Levitt (1956). He presented a formula useful in calculating the length of time a given tissue will survive exposure to a given constant temperature. Because the heat pulse induced into a body by a forest fire varies with time, it is necessary to convert Levitt's semi-logarithmic injury equation to a rate equation (Martin 1963) in fire situations.

Injury curves for Douglas-fir (*Pseudotsuga menziesii* Mirb. ***Franco***) seedlings (Silen 1960) give a value of 59.44 for the constant "a" and 2.291 for constant "b." Using these data the rate equation becomes:

$$\frac{1}{T} = e^{(0.433t-25.91)} \text{ where: t is in °C and T in minutes.}$$

Values of 1/T would then represent the possibility of lethal exposure to a given temperature.

Using this formula the cambial temperature-time curve of Figure 2 may be expanded, as in Figure 3. Area under the expanded curve would then indicate whether or not injury should occur. Preliminary studies with *Cassia nictians* L. seed have shown the above relationship to be useful but have not definitely demonstrated its validity.

Although this relationship has been discussed as though high temperature effects are primarily destructive, the rate equation might also be used in evaluating beneficial effects. Cushwa *et al.* (1968) recently explored seed scarification by high temperatures. Martin and Cushwa (1966) found that fire was effective in scarifying ***Cassia nictitans*** seed; temperature and moisture produced by the fire increased germination, but only at temperatures above 60°C.

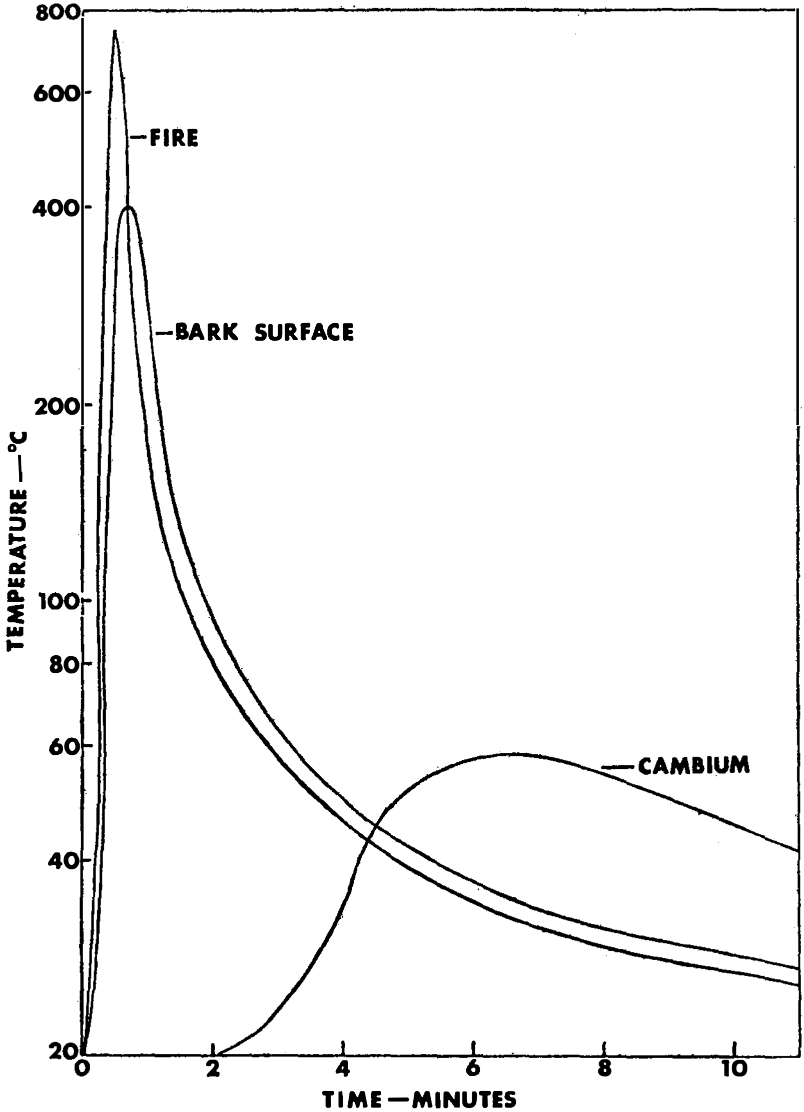


Figure 2.—A family of time-temperature curves illustrating the decrease and delay of temperature peaks within a body (from Martin 1964).

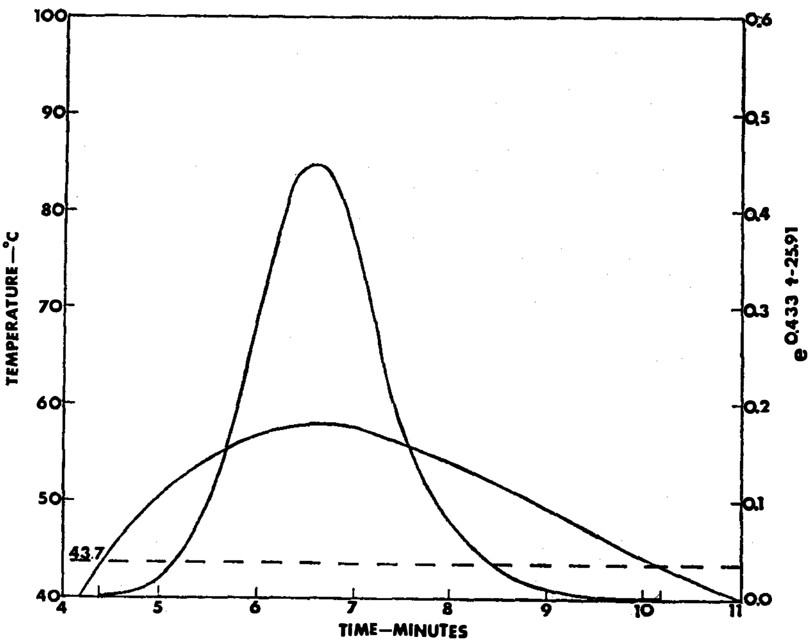


Figure 3.—Expansion of the time-temperature curve in a summative curve to evaluate possibility of tissue injury (from Martin 1964).

SUMMARY

Vegetational changes following forest fires in the southeastern United States affect the habitat of all species of wildlife, some detrimentally and some beneficially. We as researchers and managers must better understand the effects of different kinds of fire on the wildlife populations and habitat in all three physiographic provinces of the Southeast in order to wisely use this management tool. More work is needed to determine the effects of fire on various species of plants and animals, and to determine how these effects relate to the various fire parameters discussed.

LITERATURE CITED

Barrett, L. I. and A. A. Downs
1943. Hardwood invasion in pine forests of the Piedmont Plateau. J. Agr. Res. 67(3):111-123.

Beaufait, W. R.
1961. Crown temperatures during prescribed burning in jack pine. Pap. Mich. Acad. Sci. 46(1): 251-257.

Brender, E. V. and R. W. Cooper
1963. Prescribed burning in Georgia's Piedmont loblolly pine stands. J. Forest. 66(1):31-36.

Brender, E. V. and T. C. Nelson
1954. Behavior and control of understory after clearcutting a Piedmont stand. U.S.D.A. Forest Serv. Southeast Forest Exp. Sta. Pap. 44, 17 p.

Byram, G. M.
1959. Combustion of forest fuels. In Forest Fire: Control and Use, by K. P. Davis. p. 61-89. New York: McGraw-Hill Book Co.

———.
1959a. Forest fire behavior. In Forest Fire: Control and Use, by K. B. Davis. p. 90-123. New York: McGraw-Hill Book Co.
———, H. B. Clements, M. E. Bishop, and R. M. Nelson, Jr.
1966. Project fire model: An experimental study of model fires. Final rep. U.S.D.A. Forest Serv.

Cushwa, C. T.
1968. Fire: A summary of literature in the U.S. from the mid-1920's to 1966. U.S.D.A. Forest Serv. Southeast. Forest Exp. Sta., 117 p.
———, E. V. Brender, and R. W. Cooper
1966. The response of herbaceous vegetation to prescribed burning. Southeast. Forest Exp. Sta., U.S.D.A. Forest Serv. Res. Note SE-53, 2 p.
———, R. E. Martin, and R. L. Miller
1968. The effects of fire on seed germination. J. Range Manage. 21(4):250-254.
——— and J. B. Redd
1967. One prescribed burn: Its effect on habitat on the Powhatan Wildl. Mgt. Area. Vir. Wildl. 28(1):19.

Czuhai, E. and C T Cushwa
1968. A resume of prescribed burning on the Piedmont National Wildlife Refuge. Southeast Forest Exp. Sta., U.S.D.A. Forest Serv. Res. Note SE-86, 4 p.

Davis, L. S. and R. E. Martin
1960. Time-temperature relationships of test headfires and backfires. Southeast. Forest Exp. Sta., U.S.D.A. Forest Serv. Res. Note SE-148, 2 p.

Fahnestock, G. R. and R. C. Hare
1964. Heating of tree trunks in surface fires. J. Forest 62(11):799-805.

Fons, W. L., H. D. Bruce, W. Y. Pong, and S. S. Richards
1960. Project fire model. Summary Progress Rep. I. U.S.D.A. Forest Serv.
———, H. B. Clements, E. R. Elliott, and P. M. George
1962. Project fire model. Summary Progress Rep. II. U.S.D.A. Forest Serv.
———, H. B. Clements, and P. M. George
1963. Scale effects on propagation rate of laboratory crib fires. Ninth Int. Symp. on Combustion Proc: 860-866.

Goebel, N. B., E. Y. Brender, and R. W. Cooper
1967. Prescribed burning of pine-hardwoods stands in the upper Piedmont of South Carolina. Forest Res. Series 16, Clemson University. 22 p.

Harper, R. M.
1962. Historical notes on the relation of fire to forests. 1st Tall Timbers Fire Ecol. Conf. Proc.: 11-30.

Herrington, L. P.
1964. A theoretical and experimental investigation of the temperature field in tree stems. Ph.D. Diss. Yale University.

Hilmon, J. B. and R. H. Hughes
1965. Forest Service research in the use of fire in livestock management in the South. 4th Tall Timbers Fire Ecol. Conf. Proc.: 260-275.

Levitt, J.
1956. The hardiness of plants. 278 p. New York: Academic Press.
———.
1963. Thermal and other properties of bark and their relation to fire injury of stems Ph.D. Diss. Univ. Mich., Ann Arbor.
———.
1963. A basic approach to fire injury of tree stems. 2nd Tall Timbers Fire Ecol. Conf. Proc.: 151-162.

Martin, R. E. and C. T. Cushwa
1966. Effects of heat and moisture on leguminous seed. 5th Tall Timber Fire Ecol. Conf. Proc.

Martin, R. E. and L. S. Davis
1961. Temperatures near the ground during prescribed burning. Pap. Mich. Acad. Sci. 46(1):239-249.

Mumaw, D. K.
1965. Evaluation of prescribed burning in relation to available deer browse. M.S. thesis, Va. Polytech. Inst., Blacksburg, Coop. Wildl. Res. Unit. Release 65-1.

Oosting, H. J.
1944. The comparative effect of surface and crown fire on the composition of a loblolly pine community. Ecology 25(1):61-69 p.

Rothermel, R. C. and H. E. Anderson
1966. Fire spread characteristics determined in the laboratory. U.S.D.A. Forest Serv., Int. Forest and Range Exp. Sta. Res. Pap. Int. 30, 34 p.

Silen, R. R.
1963. Lethal surface temperatures and their interpretation for Douglas-fir. Ph.D. Diss., Oregon State Univ., Corvallis.

Stoddard, H. L.
1931. The bobwhite quail. 559 p. New York: Charles Scribner's Sons.

Thomas, P. H.
1963. The size of flames from natural fires. Ninth Int. Symp. on Combustion Proc.: 844-859.

Williams, Mildred B.
1938. The effect on fire on forests: an annotated bibliography. U.S.D.A. Forest Serv., Washington, D. C.

BURNING SERAL BRUSH RANGES FOR BIG GAME IN NORTHERN IDAHO

THOMAS A. LEEGE
Idaho Fish and Game Department, Kamiah

Normal plant succession is causing a continual decrease in the winter food supply for big game in northern Idaho and adjacent areas. Cooperative studies between the Idaho Fish and Game Department and the U. S. Forest Service were initiated in 1965 to evaluate the use of prescribed burning for increasing available browse on winter ranges. This paper describes some of the results of the prescribed burns and outlines the extent to which this rehabilitation technique has been put into practive.

THE PROBLEM

Many of the elk ranges in northern Idaho, eastern Washington, and western Montana have dense, conifer forests as the climax vegetation. These evergreens, primarily western red cedar (*Thuja plicata*), grand fir (*Abies grandis*), Douglas-fir (*Pseudotsuga menzesii*), western hemlock (*Tsuga heterophylla*), and western white pine (*Pinus monticola*), dominate the areas they occupy and crowd out the shrubby vegetation which provides forage for elk and deer. When climax vegetation occurs over large portions of their winter range, big game populations remain small. This was the case before large fires in the early 1900's, notably 1910, 1919, and 1934, destroyed literally millions of acres of timber. Shrubby species rapidly invaded the burned areas, and elk and deer numbers increased accordingly. Browse production is now diminishing as conifers become reestablished and crowd out the shrubs (Lyon, 1966). In addition, three of the four most abundant winter food shrubs, willow (*Salix scouleriana*), serviceberry (*Amelanchier alnifolia*), and mountain maple (*Acer glabrum*) have grown too tall to provide much forage. The other, and possibly the most important browse plant because of its low-growth form, redstem ceanothus (*Ceanothus sanguineus*), is vanishing from the shrub community, probably because of shading and old age.

The elk population has been slowly decreasing along with the browse (Leege, 1968). Only a remnant of the formerly large mule deer herd remains (McCulloch, 1955). A series of easy winters in recent years has deferred mass die-offs, and a large elk herd still exists. However, it is evident that a substandard ration is being obtained even during these mild winters because productivity is low. Aerial classification counts and check station records indicate only 20 to 35 calves per 100 cows in the fall and winter months. Areas of exception are where clear-cut logging has created new winter food patches to compensate for that which is being lost to succession.

Early Range Rehabilitation Studies:

Herbicides, primarily mixtures of 2,4-D and 2,4,5-T, have been used in an attempt to kill back the tall shrubs and promote sprouting in the browsing zone (Mueggler, 1966; Lyon and Mueggler, 1968). Results have generally been unsatisfactory and the technique is only recommended for special situations.

Cutting down tall shrubs has been attempted with good results, but high costs make it prohibitively expensive to use over large areas.

Prescribed burning was experimentally used as a rehabilitation technique on the St. Joe National Forest in northern Idaho in 1961. This preliminary study indicated that both spring and fall burning were feasible and produced desirable results (Brown, 1966).

LOCHSA RIVER BURNING STUDIES

In 1965, the Idaho Fish and Game Department and the U. S. Forest Service began a cooperative study to investigate winter range ecology and the effects of prescribed burning. The Lochsa River drainage in north-central Idaho was chosen as the study area because the vegetation adequately represents the problem area and because it has good access. Most of the drainage was burned one or more times by wildfires in the early part of this century. Because of the diversity in sites and burning history, plant communities vary from almost pure shrub stands to mature conifer forests. Elevation ranges from 1500 to 2000 feet along the river to 7000 and 8000 feet in the surrounding mountains. Slopes are predominantly steep, averaging about 60 percent. Soils are of granitic origin and porous. Precipitation ranges from 20 inches at the lower elevations to 50 inches or more in the mountains. Much of the moisture comes during the winter months as snow, forcing the big game to lower elevations where they concentrate along the major drainages. It is here that food becomes a limiting factor and where shrub fields must produce abundant browse to support the large herds. Fortunately, many of these areas are on national forest land where the importance of the game resource is considered when land-use priorities are established.

PROCEDURES AND RESULTS

Most of the research has centered around the effects of prescribed burning on the important shrub species. Study areas in Sherman and Otterslide Creeks were burned in fall, 1965, and spring and fall, 1966. Over 500 individual shrubs were tagged and measured before and after treatment. Permanent plots, 2.1 sq. ft. in size were established for evaluating changes in ground cover, woody seedlings, and low shrubs. Only plants completely top-killed by the fires, and plots entirely burned over were remeasured, except for controls. Burning techniques and some results have already been reported (Leege, 1968).

Ground Cover and Erosion:

Ground cover was divided into four categories: herbaceous, litter, bare ground, and rock. Prescribed burning had little effect on herbaceous cover but increased bare ground and decreased litter on both fall and spring burns. After the third growing season following burning, bare ground and litter were not yet back to preburn percentages, but the differences were rapidly narrowing. Fall burning more completely consumed the litter and exposed bare soil. Because of this, and because the soil remained unprotected by vegetation over the winter, fall burning caused greater erosion potential. However, erosion has been minimal except in the firelines where some gullying has occurred. The soil and humus were moist during our burns, in contrast to the dry conditions of summer wildfires, thus preventing heat penetration and the destruction of soil holding properties.

Shrub Response:

All shrub species sprouted after burning, but in varying degrees. Willow, mountain maple, serviceberry, and oceanspray (*Holodiscus discolor*) were the most prolific sprouters, producing as many as 120 sprouts per plant. Less active sprouters were redstem ceanothus, bitter cherry (*Prunus emarginata*), cascara (*Rhamnus purshiana*) and syringa (*Philadelhus lewisii*). They normally averaged between 15 and 50 sprouts per plant. Willow put on the most rapid regrowth after burning, with individual sprouts as long as ten feet following the first growing season, but averaging three to five feet high. The other shrub species normally had sprouts between one and three feet long. Plants which were burned in the fall almost always had fewer sprouts the next year than did spring-burned plants. However, the sprouts were enough longer so that about the same quantity of new growth was produced. As game do not utilize a sprout completely to its base and because the terminal portions of sprouts are more nutritious (Blair and Epps, 1967), it is important to have more sprouts, even though they may be somewhat shorter.

As mentioned previously, willow, mountain maple, and serviceberry are the three most valuable forage species which normally grow out of reach, and burning restores their availability. After three growing seasons following rehabilitation, the maximum height of all three of these species is once again above the zone of availability—arbitrarily set at 7 feet (Figure 1). However, a high percentage of the browse production is still available. The rate of growth appears to be slowing, and it is likely that it will be several years yet before crown heights approach preburn measurements. In contrast, crown diameters are already equal to or greater than before burning for willow and mountain maple.

Changes in Palatability:

It rapidly became obvious that big game preferred eating the new growth on the burned areas rather than on adjacent unburned areas. To better evaluate this apparent increase in browse palatability, we examined 177 previously tagged shrubs of eight species on the Sherman Creek study area and estimated the percentage of the number of available twigs which were utilized during the winter browsing period. We also measured the diameter where twigs were browsed off on three randomly selected twigs on each tagged shrub (Table 1). This was done after the first and second winters following burning. We could not directly compare the browse palatability on the spring and fall burns as they had been treated one growing season apart. The area burned in spring, 1966, was browsed the following winter, 1966-67, whereas the fall burn, 1966, did not have growth available for browsing until the winter of 1967-68.

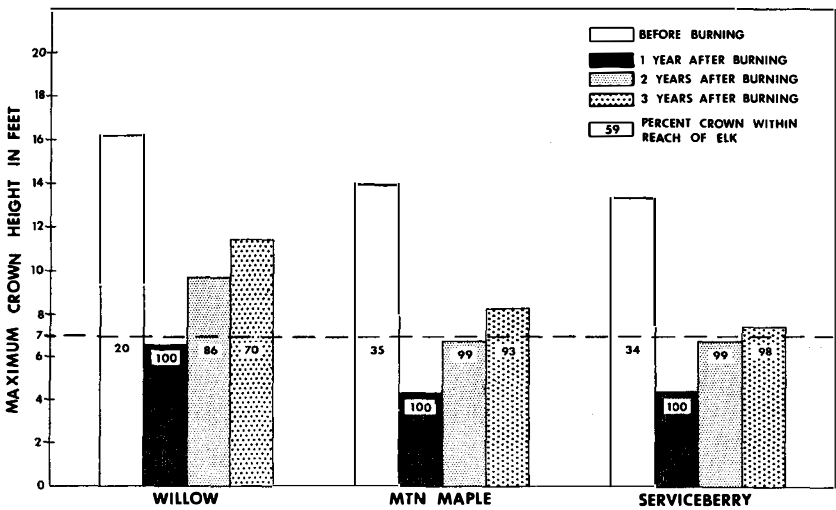


Figure 1.—Changes in maximum shrub crown height and browse availability for three growing seasons following prescribed burning. Data are combined from the spring and fall burns on Otterslide Creek and the spring burn on Sherman Creek.

TABLE 1. COMPARISON OF BROWSE UTILIZATION DURING THE WINTER MONTHS ON BURNED AND UNBURNED AREAS IN THE SHERMAN CREEK DRAINAGE

Species	Burning Date	Number plants	Percentage of twigs browsed		Browsing diameter (in millimeters)	
			1966–67	1967–68	1966–67	1967–68
Willow	Fall, 1966	7	—	75.0**	—	3.8**
	Spring, 1966	10	93.5**	84.5**	4.5**	3.3**
	Control	11	67.7	20.5	3.7	3.0
Mtn. Maple	Fall, 1966	8	—	48.8**	—	2.7*
	Spring, 1966	10	65.5**	55.5**	3.1**	2.6*
	Control	10	9.5	2.0	2.5	2.0
Serviceberry	Fall, 1966	7	—	26.4*	—	2.7
	Spring, 1966	9	56.1**	35.6**	3.5**	2.7
	Control	10	1.5	2.0	2.5	2.6
Redstem	Fall, 1966	8	—	65.6*	—	3.1
	Spring, 1966	8	91.1**	49.4	3.3	3.5
	Control	10	62.5	30.0	3.4	3.5
Bitter cherry	Fall, 1966	6	—	14.2	—	2.1
	Spring, 1966	8	43.8**	3.8	2.0	1.7
	Control	6	5.7	0.8	2.0	1.5
Cascara	Fall, 1966	2	—	45.0	—	4.2
	Spring, 1966	4	70.0	65.0	4.3	3.8
	Control	4	73.8	22.5	4.0	3.9
Ocean spray	Fall, 1966	7	—	12.1	—	2.4*
	Spring, 1966	8	23.1	6.9	2.5**	2.1
	Control	7	0.7	0.0	1.4	1.0
Syringa	Fall, 1966	5	—	20.0*	—	2.6*
	Spring, 1966	4	36.3*	30.0*	2.3	2.0
	Control	8	1.3	0.6	2.6	1.8

— No forage present during this browsing period.
* Different from control at .05 level.
** Different from control at .01 level.

The control data show that winter browsing pressure on the Sherman Creek study areas was considerably less in 1967-68, compared to the previous winter. This was due to unusually mild winter weather which permitted the game to scatter widely over the winter range.

Both spring and fall burning increased browse palatability significantly as all species were browsed heavier on burned areas. Even normally unpalatable shrubs like oceanspray, syringa and bitter cherry were eaten to a much greater extent after burning. The spring-burned area was checked again after the second winter of browsing, and all species were still preferred to the unburned shrubs on the control area. Therefore, it appears that the palatability increase is more than a temporary effect. This is in contrast to results from Missouri (Lewis, et al., 1964) and Texas (Lay, 1967) where the palatability increase was essentially lost after the first year.

The increased palatability of burned shrubs was also shown by the increase in size of twigs which elk would browse. This was especially apparent for willow and mountain maple which still had significantly larger browsing diameters after the second winter following burning (Table 1). Some of the other species were eaten to larger diameters during the first winter, but were not significantly different from the control the following winter.

Changes in Browse Nutrients:

In February, 1968, samples were collected from redstem, serviceberry, and ninebark (*Physocarpus malvaceous*) shrubs on the three Sherman Creek study areas and a burned area in nearby Boulder Creek. The Boulder Creek area was included because it had only one growing season after spring burning and was needed for comparison with the one-growing-season fall burn and two-growing-season spring burn in Sherman Creek. Three samples of redstem and serviceberry, and one sample of ninebark were collected from each of the four areas. A sample consisted of the terminal two inches of annual growth from at least one hundred twigs picked at random. The analysis of variance and Duncan's multiple range test (Steel and Torrie, 1960: 112-114) were used to evaluate the differences that occurred between the treatment areas and the control (Table 2).

Protein was consistently higher on the burned areas than the control. However, the only difference great enough to be significant was on the spring-1966 burn where serviceberry twig growth was 26 percent higher in protein than the control.

Crude fiber was significantly higher on two burn areas for serviceberry. On the fall-1966 burn, crude fiber was 23 percent higher than the control while on the spring-1967 burn it was 24 percent higher.

Nitrogen-free extract was usually slightly lower on burned areas and significantly so in three cases where the decreases averaged between 6 and 8 percent.

Ash was somewhat higher on the burned areas, but the differences were not significant.

The phosphorus content of ninebark increased about 40 percent after burning; however, the other two species showed no important changes.

The spring-1966 burn was the only area where two growing seasons had occurred since treatment. In almost all cases, the changes in nutrient quantities on this area were equivalent to the other burn areas which had only one growing season. This would indicate that nutrient changes brought about by spring burning would last for at least two winter browsing seasons.

Lay (1957), in Texas, concluded that burning at any season increased protein and phosphoric acid content of browse, but that most of the benefits disappeared within a year or two. The increase in browse protein was still evident two years after a high-intensity burn in Maryland (DeWitt and Derby, 1955); whereas the increase was only significant for one year on a low-intensity burn.

Einarsen (1946) also found higher protein values for browse on areas recently burned. He reported that browse protein decreased as

TABLE 2. NUTRIENT ANALYSIS OF TERMINAL TWO INCHES OF ANNUAL GROWTH ON A CONTROL, A FALLBURN, AND TWO SPRINGBURN AREAS.[1,2]

Species Area and Treatment date	Protein	Fat	Crude Fiber	Nitrogen-free Extract	Ash	Calcium	Phosphorus	C:P Raatio
Redstem Ceanothus								
Sherman Cr., Control [f]	9.20	1.97	24.64	60.21	3.97	1.28	0.32	4.0:1
Sherman Cr., Fall 1966	9.47	1.29	24.78	60.46	3.99	1.23	0.19	6.4:1
Sherman Cr., Spring 1966	9.94	2.56	26.63	56.86*	3.99	1.29	0.28	4.6:1
Boulder Cr., Spring 1967	9.43	2.28	25.79	58.17	4.32	1.40	0.29	4.8:1
Serviceberry								
Sherman Cr., Control	8.07	4.07	20.76	62.74	4.34	1.28	0.29	4.4:1
Sherman Cr., Fall 1966[f]	9.90	2.45	25.45*	57.57*	4.62	1.26	0.23	5.5:1
Sherman Cr., Spring 1966	10.18*	2.82	21.45	60.84	4.68	1.36	0.30	4.5:1
Boulder Cr., Spring 1967	9.26	2.44	25.77*	57.85*	4.66	1.31	0.20	6.5:1
Ninebark[3]								
Sherman Cr., Control	6.93	2.39	25.88	61.55	3.25	1.10	0.21	5.2:1
Sherman Cr., Fall 1966	9.04	2.91	25.96	57.81	4.28	0.89	0.33	2.7:1
Sherman Cr., Spring 1966	7.88	2.23	25.39	60.06	4.44	0.90	0.26	3.4:1
Boulder Cr., Spring 1967	7.40	1.29	30.98	55.88	4.45	0.98	0.30	3.0:1

[1] All measurements in per cent of total dry weight.
[2] Samples collected in February, 1968.
[3] Only one sample of ninebark was collected from each treatment area, so means were not statistically analysed.
[f] Only two samples, instead of three, are included in these averagee.
* Different from control at .05 level.

succession advanced toward canopy closure in the coastal range of Oregon.

Woody Seedlings:

Numerous woody seedlings, primarily redstem and bitter cherry, appeared on our study areas after they were burned. Redstem is the species of primary interest because of its high value as winter forage, and because its numbers have declined in many of the older brushfields. Fall burning stimulated approximately 242,000 redstem seeds per acre to germinate the following spring (Hickey and Leege, 1969). Spring burning produced about 60,000 redstem seedlings per acre, most of which came the following spring also. Redstem seed normally lays dormant in the soil for many years as it takes heat or abrasion to make the seed coat permeable to water so that it can complete its development and germinate (Glazebrook, 1941). Apparently, the heat from fall burns penetrated the soils deeper and stimulated a greater seed response. It may also be that the fall fires more closely approximated the summer wildfires for which redstem has adapted—in terms of providing heat just before a period of cold weather when the seed can complete its development. The hot summer months after spring burns may upset this ripening and stratifying schedule to some extent. At any rate, both spring and fall burns produced adequate seedlings to restock the areas. Thereafter, seedling survival is the factor which determines the density of redstem plants in a maturing brushfield.

STATUS OF PRESCRIBED BURNING PROGRAM

Forest Service administrators have recognized for some time that the seral brush ranges supporting our large elk herds needed to be rejuvenated. But the techniques for manipulating large quantities of habitat on a limited budget were not available. The advent of prescribed burning, especially spring burning, has reduced the cost to where now it is feasible to treat the large acreages necessary. On three national forests in northern Idaho which burned almost four thousand acres last spring, 1968, the average cost was $.71 per acre (Foulger, 1968). Burning costs are steadily decreasing as more experience is gained.

The prescribed burning for wildlife program is still in its infancy. But confidence is growing with experience and steady progress is being made. The first large burns to rejuvenate ranges were made in 1965 when 1016 acres were treated in northern Idaho and adjacent areas in Washington and Montana. Since then, 2276 acres were burned in 1966, 2495 acres in 1967, and 4652 acres in 1968. The goal is set for 7700 acres in 1969 (Foulger, 1968). Much remains to be done as acreages in need of rehabilitation are numbered in the hundreds of thousands. But, with continued interest in improving winter ranges by our public land managers, this region should have large big game herds for years to come.

SUMMARY

Large wildfires in the early 1900's created thousands of acres of browse-laden winter ranges where conifers formerly dominated in northern Idaho and adjacent areas in Montana and Washington. Big game multiplied and thrived until natural plant succession reduced carrying capacity. A cooperative state-federal research project began investigating the use of prescribed burning to set back succession on winter ranges in 1965. Initial results were encouraging as tall shrubs provided abundant sprouts within browsing reach and numerous redstem ceanothus seedlings invaded the burns. Browse nutrients were higher in the new growth which followed the burning treatments and palatability also increased. Erosion has been minimal because of the soil being moist when burning was done. The use of prescribed burning as a range rehabilitation technique is being accepted, and burned acreages have increased from 1016 in 1965 to 4652 in 1968. The goal is 7700 acres for 1969.

ACKNOWLEDGMENTS

The study findings reported herein were gathered under Idaho Federal Aid Project W-85-R. Mr. W. O. Hickey, Jr., Idaho Fish and Game Department, assisted with the collection and tabulation of much of the data, and reviewed the manuscript, for which I am grateful. The United States Forest Service has cooperated in this research from its beginning. Personnel of the Clearwater National Forest burned study areas when requested and supplied materials and assistance. I would especially like to thank Mr. D. R. Jenni, forester, for his continuous support and for reviewing this manuscript. Nutrient analyses were conducted by the Agricultural Biochemistry and Soils Department, University of Idaho, Moscow.

LITERATURE CITED

Blair, R. M. and E. A. Epps, Jr.
1967. Distribution of protein and phosphorus in spring growth of rusty blackhaw. Jour. Wildl. Mgmt. 31(1):188-190.

Brown, R. L.
1966. Avery face browse rehabilitation study, final report. U.S. Forest Service, St. Joe National Forest, St. Maries, Idaho. Mimeo. 9 pp.

DeWitt, J. B. and J. V. Derby, Jr.
1955. Changes in nutritive value of browse plants following forest fires. Jour. Wildl. Mgmt. 19(1):65-70.

Einarsen, A. S.
1946. Crude protein determination of deer food as an applied management technique. Eleventh N. Am. Wildlife Conf. Trans. 309-312.

Foulger, H.
1968. Personal correspondence. In files of T. Leege and Regional Office, U.S. Forest Service, Missoula, Montana. Rf. 2610 and 2630.
Glazebrook, T.
1941. Overcoming delayed germination in the seed of plants valuable for erosion control and wildlife utilization. M. S. Thesis. Univ. of Idaho, Moscow. 97 pp.
Hickey, W. O. and T. A. Leege
1969. Management and ecology of redstem ceanothus—a review. Idaho Fish and Game Dept. Bull., Boise. (in press).
Lay, D. W.
1957. Browse quality and effects of prescribed burning in southern pine forests. Jour. of For. 55(5):342-347.
————.
1967. Browse palatability and the effects of prescribed burning in southern pine forest. Jour. of For. 65(11):826-828.
Leege, T. A.
1968. Prescribed burning for elk in northern Idaho. Proc. Seventh Ann. Tall Timbers Fire Ecol. Conf. Tall Timbers Res. Sta. Tallahassee, Fla. (in press).
Lewis, J. B., D. A. Murphy, and J. Ehrenreich
1964. Effects of burning dates on vegetative production on Ozark forests. Proc. Southeastern Assoc. Fish and Game Comm. Conf. 18:63-72.
Lyon, L. J.
1966. Problems of habitat management for deer and elk in the northern forests. Int. For. and Rge. Exp. Sta. Res. Paper INT-24. Ogden, Utah. 15 pp.
———— and W. F. Mueggler
1968. Herbicide treatment of north Idaho browse evaluated six years later. Jour. Wildl. Mgmt. 32(3):538-541.
McCulloch, C. Y. Jr.
1955. Utilization of winter browse on wilderness big game range. Jour. Wildl. Mgmt. (19(2):206-215.
Mueggler, W. F.
1966. Herbicide treatment of browse on a big-game winter range in northern Idaho. Jour. Wildl. Mgmt. 30(1):141-151.
Steele, R. G. and J. H. Torrie
1960. Principles and procedures of statistics with special reference to the biological sciences. McGraw-Hill Book Co., Inc. 481 pp.

PRESCRIBED BURNING FOR WILDLIFE IN CALIFORNIA BRUSHLANDS

HAROLD H. BISWELL
School of Forestry and Conservation, University of California, Berkeley

Prescribed burning, also known as control burning, is the judicious use of fire for a constructive purpose and according to a management plan. Its objective is to employ fire scientifically for maximum net benefits at minimum damage and acceptable cost. In selected places and under proper management and control, prescribed burning can be a useful tool in the manipulation of brushlands for wildlife.

Decisions about prescribed burning will vary from place to place because California's brushlands vary greatly in plant species composition, kind of soil and steepness of slope, availability of water, wildfire danger, surrounding vegetation types, and related uses. They also vary from semi-open groves of oaks and woodland-grass chaparral growing on rolling foothills to dense stands of brush covering steep mountain slopes. Some shrubs put out crown sprouts after fire; others reproduce only from seed. Some areas have been in brush for as long as records have been kept. In other places brush has been the invader, and has become so thick that the carrying capacity for wildlife has declined (Biswell, 1957). Such variability requires that a prescription be prepared for each area to be burned. In addition to providing an improved wildlife habitat, each prescribed treatment may result in associated benefits. These include improvement of grazing for livestock, more effective and less costly wildfire control, increased water yields, reduction of soil erosion and sedimentation of streams and reservoirs, and improved access for hunting and recreation.

In 1945 the State Legislature authorized the California Division of Forestry to issue control-burning permits for purposes of brush-range improvement. Since that time more than 2.3 million acres of private lands have been burned under permit. In addition, some burning has been done outside of the fire season when permits were not necessary. The U.S. Forest Service and the Bureau of Land Management have also done considerable prescribed burning on the lands under their jurisdiction.

Some of the prescribed burning under permit has been done exclusively for wildlife, mainly in chamise chaparral, but the majority has been done by ranchers to improve grazing for livestock. When burning is done to improve forage for livestock, however, conditions for wildlife are usually improved also. Furthermore, brushlands are often converted to grasslands by fire and other treatments intended to reduce wildfire hazards and to make wildfire fighting more effective and safer, thus improving conditions for wildlife.

Much research on prescribed burning has been done since 1945 by the California Division of Forestry and other interested agencies, including the University of California, the Pacific Southwest Forest and Range Experiment Station, and the California Department of Fish and Game. The National Park Service recently initiated research in the use of fire to re-establish and maintain natural landscapes, recognizing that fire has always been an important ecological factor in the mountain areas. Results of research on manipulating vegetation with fire have been widely published. Perhaps the best single source of information is the Proceedings of the Tall Timbers Fire Ecology Conference held at Hobergs, California, in 1967.[1]

For 12 years the University of California at Berkeley and the California Department of Fish and Game conducted cooperative studies on "The effects of brush removal on game ranges in California" (projects California 31-R and 51-R) with funds provided by the Federal Aid in Wildlife Restoration Act. The use of fire in chamise chaparral in the north coast region, in Lake County, about 100 miles

[1]This publication is available free by writing to Mr. E. V. Komarek, Tall Timbers Research Station, Rt. 1, Box 110, Tallahassee, Florida 32301.

northeast of San Francisco, was studied for six years and for another six years in woodland and woodland-grass chaparral on the San Joaquin deer winter range on the west side of the Sierra Nevada east of Fresno, at elevations of 2,000 to 5,000 feet.

STUDIES OF PRESCRIBED BURNING IN CHAMISE CHAPARRAL

In general, two cover types comprise this brushland—one in which chamise (*Adenostema fasciculatum*) predominates on the south-facing slopes, the other a mixture of tall shrubs and small trees on north-facing slopes. The intermixture of types is especially favorable for deer, and there is sufficient water in the ravines. In addition to chamise, other abundant shrubs include wedgeleaf ceanothus (*Ceanothus cuneatus*), deer brush (*C. integerrimus*), western mountain mahogany (*Cecocarpus betuloides*), chaparral pea (*Pickeringia montana*), Eastwood manzanita (*Arctostaphylos glandulosa*), interior liveoak (*Quercus wislizenii*), yerba santa (*Eridictyon califoricum*), and others. For the most part, chamise chaparral is dense and there may be little or no herbaceous vegetation in the understory.

Like all wildlife, deer have certain environmental requirements for optimum production. Among these are year-long palatable, nutritious forage, cover for escape and perhaps resting, and drinking water. The absence of any one of these factors may make an area largely, or entirely unsuitable for deer. With these requirements in mind, studies were made of deer populations in three areas of chamise: (1) opened brushland consisting of small burned patches here and there, seeded to suitable herbaceous species for winter and early spring forage; (2) heavy, unburned brush that served as a control; and (3) an area burned by wildfire so intense that no unburned patches remained to serve as cover. Each area covered about 1,000 acres. These cover conditions will be referred to as opened brush, heavy unburned brush, and wildfire burn. The deer in the general area of the treatments are resident rather than migratory, but they do make short seasonal movements. Counts of deer in opened brush gave a summer population density of about 98 per square mile after the initial brush-manipulation treatment. This figure rose to 131 the second year, and then dropped to about 84 in the fifth and sixth years, at which point the population presumably stabilized. Measurements in the heavy, untreated brush gave a summer density of only 30 deer per square mile. In the summer following the wildfire burn in dense brush, the deer had increased to 120 per square mile. Some of this increase was due to influx from the areas immediately surrounding the burn. As the wildfire burn area grew older, the population fell to 106 the second year, 52 the third, and 44 the fourth. Eventually it will reach the same status as in the heavy, untreated brush—probably in 12 to 15 years. In opened brush, fawn production was about 145 fawns to 100 does; in heavy brush, 71 to 100; and in the wildfire burn, 115 to 100. (Biswell *et al.*, 1952; Taber and Dasmann, 1958).

It was noted that opened brush and wildfire burns offered summer diets of higher quality than did the heavy, untreated brush. The deer weights reflected essentially this same relationship, those in the wildfire burn being highest in animals on the wildfire burn and lowest in those on the dense brush. The difference between the extremes was about 13 pounds.

Peak weights for bucks in the opened brush and the wildfire burn were reached in July. From that point weights declined. Bucks in dense brush retained their fall condition better than did bucks on other ranges, probably because the acorn supply was greater. The advantage conferred by the acorn crop is short-lived, however. From an October high of 9 pounds above average, the buck weights fell rapidly to a February low of 39 pounds below average. Weights of the animals on the wildfire burn dropped low in February, too, probably because of a shortage of grasses and forbs. The bucks from opened brush with nutritious grasses and forbs maintained their conditions well through the winter.

In the light of these results, the general objective in management apparently should be to reduce the brush cover in spots and introduce palatable, herbaceous species for use in winter and early spring.

Manipulation can completely replace brush by grasses in spots, or it can thin the shrubs in spots to make room for grasses to grow also. In the first case, browse is provided along the edges of openings, and grasses and forbs are abundant for winter and spring use. In the second case, browse comes from the scattered shrubs in the openings as well as from the edges. The latter solution should provide a greater total quantity of browse than the first method. The principal advantage of the first method is that growth of the grasses in the open spots is dense thus providing more complete cover and protection for the soil.

Opening dense chamise brushland results in a desirable interspersion of food and cover. Once chamise brushlands are properly opened and the growth of herbaceous species is encouraged, good management should keep them productive over a long period of time with a minimum of further disturbance.

Converting spots of mixed-chamise brush to grass is usually done where the slope is less than 40 percent. The brush may be mashed with a bulldozer and burned. The area is then reseeded to suitable grasses, and later sprayed and resprayed with herbicides to obtain complete conversion. Fertilizers may be necessary to maintain grassy spots once they are established. Another technique is to reseed and spray spots on wildfire burns to create openings. This has been done frequently in the past few years, not so much for wildlife but to make wildfire control easier, cheaper, and safer for fire fighters.

A second technique for creating openings is to surround an area with fire-breaks and then burn the standing brush under conditions in which the fire spread is not complete. This leaves unburned spots. Reseeding follows the burning. In this technique about 27 percent of the mature chamise plants are killed by the fire, and the reseeded grasses thin the seedlings so that the eventual mature brush stand is not so thick as it would have been without the reseeding. For wildlife, this solution is good, but from the standpoint of an eventual watershed cover it may be bad.

Still another technique is to strip burn in early spring in suitable places, without firebreaks and without reseeding. Volunteer herbs will appear, but the brush stand will be thicker, and perhaps furnish a better watershed cover later on, than if it had not been burned and reseeded. This method needs further investigation as a means of rejuvenating brushlands and keeping down wildfire hazards as well as improving conditions for wildlife.

STUDIES OF PRESCRIBED BURNING IN WOODLAND AND WOODLAND-GRASS CHAPARRAL

The topography of the San Joaquin deer winter range is rough and rocky, but there are gently sloping benches and ridgetops. About 20 percent of the area has slopes of less than 40 percent or is rock free where bulldozers could be used without difficulty. Ponderosa pine grows on the upper side of the winter range, and presents an extreme fire hazard from debris accumulation.

The principal shrubs on the deer winter range are western mountain mahogany, flannel bush (*Fremontia californica*), redberry (*Rhamnus crocea* var. *ilicifolia*), interior liveoak, mariposa manzanita (*Arctostaphylos mariposa*), Yerba santa, wedgeleaf ceanothus, whitethorn chaparral (*Ceanothus leucodermis*), and cherry (*Prunus subcordata*). The brush stand was old and decadent, and produced only 13 to 106 pounds of browse per acre yearly (Gibbens and Schultz, 1963). After fall and early spring burns, browse increased to 750 to 2,750 pounds per acre. Late spring burning was less effective, and the increase in browse was not so great. When burned areas were reseeded, the grass production increased from a low of 400 up to 1,500 pounds.

Woodland and woodland-grass chaparral does not burn as readily as chamise. The procedure in manipulation was to mash the brush with a bulldozer, dry it for about six months, and burn it under weather and moisture conditions that would lessen the danger of fire escaping into the area of ponderosa pine above. Fire was set on some areas in the fall, after rains had started, and on others in the early spring. Both fall and early spring burning proved effective in getting large numbers of wedgeleaf ceanothus and whitethorn chaparral seedlings, two of the more valuable browse species. Fire is essential in bringing about good seed germination of these two nonsprouting species.

After burning, the area was reseeded to suitable perennial and annual grasses. These were heavily utilized by deer in spring and by cattle during the summer. There was some question about the wisdom of reseeding because the grasses choked out so many of the seedlings of nonsprouting shrubs.

Even though fall and early spring burning and reseeding greatly increased the browse and forage for deer, utilization each year was heavy—up to 80 percent—and there was no measurable effect on deer productivity. Only about 20 percent of the terrain was smooth enough to be covered by a bulldozer, and only that much of the brushland was manipulated. The deer concentrated on that portion. If fire alone had been used as a manipulation tool, it would have been possible to manage areas inaccessible to bulldozers—the other 80 percent of the deer winter range. New sprouts and seedlings on a number of wildfire burns in the general area attest to the effectiveness of fire alone in stimulating greater production of browse.

DISCUSSION

Fire is an effective tool in manipulating brushlands to increase browse and improve cover conditions for wildlife. For some of the nonsprouting species, such as wedgeleaf ceanothus and whitethorn chaparral, fire is essential to crack the hard seedcoats so that the seeds can absorb water and germinate. However, for some of the sprouting species, such as western mountain mahogany, sprouts follow mashing with a bulldozer, and fire is not essential.

Fire is essential for nonsprouting species. On the other hand, if a second fire occurs before the new plants produce seed, the stand of brush may be destroyed completely. Therefore, the protection of new stands of brush against fire is just as important in the management of brushlands for wildlife as using fire in the first place to get new seedlings.

When the carrying capacity of brushlands has been increased by prescribed burning, it becomes doubly important to control deer populations (Jordan, 1967). Large numbers of deer on heavily utilized slopes trample and stir the soil in wet weather, thus leading to accelerated erosion. Furthermore, deer numbers should be regulated to permit the nonsprouting species to grow up and produce seed within a reasonable period of time—possibly 15 years. A portion of the San Joaquin deer winter range was burned by a wildfire in 1939. An excellent stand of nonsprouting species followed the fire, but because of heavy utilization, very few if any seeds have been produced since that time. Erosion has been rather severe on the steep slope, indicating that the range has been overutilized.

LITERATURE CITED

Biswell, H. H.
1957. The use of fire in California chaparral for game habitat improvement. Pro., Soc. American Foresters, Syracuse, N. Y.: 151-155.
Biswell, H. H., R. D. Taber, D. W. Hedrick, and A. M. Schultz
1952. Management of cbamise brush for game in the north coast region of California. California Fish and Game. 38(4):453-484.
Gibbens, R. P., and A. M. Schultz
1963. Brush manipulation on a deer winter range. Fish and Game 49(2):95-118.
Jordan, P. A.
1967. Ecology of migratory deer in the San Joaquin River drainage. Ph.D. Thesis, Graduate Div., Univ. of Calif., Berkeley, pp. 1-278.
Taber, R. D., and R. F. Dasmann
1958. The black-tailed deer of the chaparral. Game Bulletin No. 8, pp. 1-163. Calif. Dept. of Fish and Game, Sacramento, Calif.

PANEL DISCUSSION

MR. JOSEPH F. PECHANEC (Utah): In very recent years, in connection with prescribed burning, we have had a new parameter come in—air pollution. I'll ask two questions and the panel can try and answer them.

To what extent has air pollution been considered in prescribed burning in these areas and if it has been considered, what is being done about about getting answers so we may be permitted to use prescribd burning in the face of standards that are being set?

MR. BISWELL: This has been quite a problem in California, and quite detailed studies were made of the contribution of prescribed burning to the smog problem. In the five county areas around San Francisco records were made of all types of burning, agricultural burning, prescribed burning of brushlands, and the burning of trimmings from crop trees, orchard trees and so forth. This study showed that all this burning contributed only one day of the total amount of smog in this area compared to 364 days of the smog problem.

MR. MACGREGOR: In California we have had a real problem with air pollution due to not just prescribed burning, but to an increased use by agricultural burners. We have agreed voluntarily not to burn when an inversion exists. We are getting forecast data from the Weather Bureau on impending inversions, and generally agriculturists in our state do not burn when we have this inversion.

MR. E. V. KOMAREK (Florida): For some unknown reason, there has been considerable concern in the last year or two about air pollution by prescribed burning and I have yet to hear anybody say anything about it in connection with slash burning. On a clear-cut tract of land when you burn the slash, you put a lot more smoke in the air than you'll ever put in with prescribed burning.

MR. CRAWFORD: Could we get some rough cost comparison on controlled burning between the different regions?

MR. LEEGE: We're talking primarily about spring burning because in the northern Rockies prescribed burning of land for wildlife is all done in the spring because there is less danger of it spreading, primarily, and it seems to work best at that time. Prescribed burning of 4000 acres last year cost 71 cents per acre. You'll have to ask what that 71 cents includes, but that's the figure I received. Prescribed burning in the fall costs considerably higher because it involves building a fire line.

DR. CUSHWA: In the Piedmont area the cost is somewhere around a dollar an acre, but it depends on the size of the area and the amount of protection needed. In the Southeast in general, in 1964, the cost was about six cents an acre on some refuges.

MR. BISWELL: In some larger areas it might be 40 cents an acre or at least less than one dollar. We bulldozed one area to get it in a burnable condition. This cost $15 an acre. We then reseeded this area which costs more than $2 an acre and then, if we spray, it means additional cost; so that the total might be up to $20 per acre.

MR. KOMAREK: This has come up for the last 30 years. Much of the cost can be attributed to slash burning and not the use of controlled burning. Also, the cost depends upon the size of the acreage and the kind of vegetation. I recently returned from Augusta, Georgia and they were burning 30 thousand acres in an afternoon by airplane. This was done for three to four cents an acre on our game lands in the Southeast.

MR. PERKINS (International Paper Company): What it costs International Paper Company to burn depends entirely on whether or not the area to be burned is within cost. Generally, anyone is afraid to burn if they don't know what they are doing. We burned 17 thousand acres for three or four cents an acre. Now, this is strictly a matter of knowing what you are doing. If you're afraid of the first, you go out with four times as much man power as you need.

MR. DALE JONES (New Mexico): Do you feel it is advantageous to wildlife to maintain openings or would it be better to allow it to come back naturally?

MR. BISWELL: We plan to manipulate up to say 85 percent of the land and keep it in different stages of return. This is where we are not converting completely to grass; if it is properly managed, this shrubbery will last, and so the treatment doesn't have to be done again.

MR. JONES: From your own findings how do you feel it relates to wildlife to create grass areas?

MR. BISWELL: This is a type of conservation. Burning will produce grass and will make some of the shrubbery to be reinstated come back healthier.

MR. MCGREGOR: Mr. Biswell pointed out that a real part of this has been the control of animals. It has been shown over a long period of time that continued use by deer and by domestic livestock converts an area from a shrub land which is not too productive into a browsing shrub land, and eventually into nothing. Certainly from a deer's standpoint this greatly reduces the original production.

MR. C. J. PERKINS: This is not so much in the form of a question as it is in the form of a statement.

These papers deal with research to find out what areas are capable of supporting wildlife. Now, in doing this we must look at the future and say what is expected from forestry.

I can show you a 21-year old plantation that was planted on a field that was relatively sterile of browse species at the time. We burned this field and then replanted. After that it came alive with deer browse and turkey and quail food.

Now, my question is has anybody else had the guts to go in and burn, and what were your results?

MR. BISWELL: We have been doing a little burning in California. We have tremendous fire hazards and wilfires which are big problems to land management in California.

The browse species developed because of fire. If we take fire away, we have all kinds of problems. By using fire after cutting, we then have a rotation cycle which increases the browse. In one area we are studying a program of burning and, as Mr. Perkins mentioned, the browse and vegetation increased after burning and deer love to browse on these areas. So wildlife can be increased in these areas from prescribed burning and the big benefit is in reducing wildlife hazards.

MR. FRANK BARICK (North Carolina): I manage an area and we annually burn from 10 to 15 thousand acres, roughly at a cost of between 25 and 50 cents per acre.

MR. GOLDWIN (New York State): As far as I have understood from what has been said, this burning has all been on private land. Has any burning been done on state or national forests or parks?

DR. CUSHWA: I'm not sure how much land is actually burned in the Southeast by the U.S. Forest Service each year, but they do have a very active program. I know they have prescribed burning being used in management on the refuges. Much of the burning is on private property rather than on state or federal lands.

MR. BISWELL: The National Park Service has started prescribed burning this past year in California. At this time I think they have burned a little over 1000 acres. They are trying to restore fire to these parks as a part of the park ecology.

MR. GENE OREN (Department of the Army): We burn about a quarter of a million acres of pine land in the South each year and we're starting to get some bad reactions from the standpoint of air pollution. Even now we're reconsidering what we might do with machinery in case reaction reaches a point where we have to cut down our burning.

Just recently an ordinance came to us from one of the local towns saying that we can't burn at any time.

MR. MACGREGOR: Unless you burn so it does not offend the general public, that is what you are going to be faced with. If you burned at night, you don't have that inversion and the general public isn't aware that the burning is going on.

MR. OREN: We have done some work with air pollution in relation to burning so that when we meet with groups that are setting standards, either at county or state levels, we have some rather definite proof to show that we can burn at times when it would not contribute to air pollution and that it would be harmful to nature if we don't burn.

DR. CUSHWA: Mr. Pechanec, could you expand a little more on the work at Riverside and Missoula where we have active programs along this line in progress in the Forest Service?

MR. PECHANEC: We have some programs under way, but these are related to slash burning. Nowhere is there the adequate coverage that is needed. I don't know if there is anything at the southeastern laboratories, but where I am, they are doing some work on air pollution,, particularly in studying the atmospheric conditions where you get dispersion of the smoke rather than a settling down. We're doing this in the Rocky Mountains. As to some of the other applications that you have discussed, I know of very little work where we have brought air pollution people into our research program.

MR. BYELICH: During our discussions here, there were statements about sprays. I'm assuming you mean herbicides. Just what is the effect of a herbicide spray on a plant community?

MR. BISWELL: Well, in range management if deer browse closely, there is always the tendency for invaders to increase and for the better species to decrease. Herbicide sprays are useful in keeping down unwanted species. They can be carried too far in getting rid of too much shrub cover and creating too much grassland without enough browse. We have to weigh very careful in dealing with wildlife just how much herbicides should be used.

PART III
CLOSING GENERAL SESSION

GENERAL SESSION

Wednesday Afternoon—March 5

Chairman: Elvis J. Stahr
President, National Audubon Society, New York City, N. Y.

Vice Chairman: William M. Blair
Reporter, New York *Times,* Washington, D. C.

ACTIONS NEEDED FOR THE TASKS AHEAD

REMARKS OF THE CHAIRMAN

Elvis J. Stahr

I shall not say very much all afternoon; but, on the other hand, I would like to say that I am delighted and honored to have been asked to chair this general session of this great Conference. I suppose that the reason that Alan Simpson was asked to chair the opening session and I to chair the closing session is because there is a prevailing sentiment in our society that anybody who can preside over a college or university these days can preside over anything.

Dr. Gabrielson and Pink Gutermuth are two of the giants in our field, and any time they ask me to do anything I am glad to do it. If they had not asked me to do this particular thing, I would have applied for it because we do have a truly distinguished and exciting panel to present to you this afternoon, and I consider it a privilege to be on the same platform with them.

This business, for example, of having the president of the National Audubon Society preside at a session of the North American Wildlife and Natural Resources Conference, I think, is additional evidence that our conservation movement is not only increasingly evangelical but increasingly ecumenical. This is a step in the right direction.

Perhaps some of you will remember what Emerson said some hundred years ago: "It staggers the imagination to contemplate how much more could be accomplished in this world if nobody cared who got the credit." I commend that to all of our organizations. Let's work together and share the credit, and sometimes the blame, for all that any of us are able to accomplish.

POPULATION, RESOURCES, AND THE GREAT COMPLEXITY[1]

DURWARD L. ALLEN
Department of Forestry and Conservation, Purdue University, Lafayette, Indiana

Over the past quarter-century, an increasing body of scientific leadership has been concerned with the accelerating increase of world population. Since the early forties it is evident that major advances in the control of infant mortality and epidemic disease (see Newman, 1965), as well as aid to areas of food shortage, have reduced death rates in many tropical countries by about half. Humanity as a whole is in a logarithmic phase of the population curve. The 3.5 billion people now inhabiting this globe are on the way to doubling by the end of the century. Unless strenuous counter measures are taken, in the United States our 200 million citizens will be more than 300 million in the same period.

In 1968 approximately 70 million people were added to this earthly habitat. The rate of addition is increasing, and it is reasonably certain that there will be a billion more people to support in another decade. It is a looming threat that already more than half the world's people are underfed, and there is literally nothing to spare for those upcoming millions. A great volume of recent literature has treated the subjects of world food supply and population. Notable summaries are Borgstrom's book, *The Hungry Planet*, (1965), the President's Science Advisory Committee report, *The World Food Problem,* (1967), and *Famine 1975* by William and Paul Paddock (1967).

Although food production technology has made important recent gains and food scientists are making every effort to rescue mankind from major disaster, there appear to be few authorities who expect such efforts to overtake the irruption of human numbers. There is, instead, a growing concensus that the chance of avoiding a demographic reckoning in the so-called "developing" countries is small, and within twenty years hundreds of millions will be faced with a debacle of starvation and its associated ills.

This is the context in which we must consider our policies and programs in North America. Many have pointed out that we are inextricably entangled in affairs of the world, and that the amplified scale of human misfortune is our doing—through acts of beneficence to nations who could not control their birth rates, especially without the help we were unwilling to give.

We are deeply involved at present in food shipments to the needy,

[1]Journal paper number 3650 of the Purdue Agricultural Experiment Station.

and technology is being exported at an increasing rate. Fortunately, there is growing appreciation that population limitation is essential and inevitable in this nation and elsewhere. The United Nations has finally become active in the field, and commendable progress has been made in our own Congress and in the Executive Branch of the government. This is in contrast to the apathy that long-blocked action while the problem grew to proportions that could not be denied.

It is still a fact of life that our leadership is not in depth. It is a leadership of informed and concerned individuals, diluted by the attitudes of the many who, with an ear to the political ground, do not yet hear the tramp of approaching millions. As this situation changes, we may expect to see greater appropriations for bio-medical and social studies of population control. There will be demographic aid to other nations on a scale demanded by the world crisis. Intimately involved with these approaches must be further enlightened consideration of the environmental problems that appear on every side.

BIOLOGICAL ANALOGIES

Although some sociologists and economists will not agree, I postulate that the problems of human welfare are biological, behavioral, and economic—in that order. There are no interfaces where one leaves off and another begins. The whole gamut of conditions and variables is something new in the way of an ecological complex. Understanding and solutions require the detailed knowledge of specialists and also the broad appraisal of the generalist. Such a generalist usually is a biologist who has extended his interests into the problems of human society enough to communicate with the specialists. The time is not far ahead when generalists will be appointed to high government commissions and committees.

My present purpose is to suggest relationships that can help understand the nature of the vast array of issues and problems that plague mankind increasingly with each passing year. It may be that we do not fully grasp what is happening to us and that a reexamination of primordial adjustments will be profitable. It can be assumed that long before the human line became human there were millions of years of evolution in which the ancestral stock occupied its functional niche in the ecosystems in which it was found. Probably we pay penalties when the primitive inner man is outraged too far, and there could well be clues to rights and wrongs in the social and habitat adaptations of common animals. A few of these characteristics are so nearly universal they are worth reviewing.

In our latitude, the young of most species are born in spring and summer, and they develop to a "subadult" stage in late summer and fall. These adolescents commonly wander widely in a "fall shuffle," evidently seeking a place to live. The farther such individuals move in strange country, the higher their mortality rate. They are at every kind of disadvantage, including the need to invade desirable space already occupied by their own kind.

When the wanderer finds a location where food, cover and other requisites are in useful combination, it settles down into a "home range." This is a unit of habitat where the animal becomes familiar with the terrain, develops its routes of travel, knows the location of every necessity, and is best able to escape from enemies. Seasonally, at least, it does not leave the security of its home range. Here it has relationships of tolerance with other individuals of the same species whose ranges overlap. A high-quality home range is a small one, where daily needs can be fulfilled with a minimum of movement. Both economic security and behavioral ease are found by the animal in its own familiar surroundings. Residents tend to display antagonistic behavior toward strangers.

Let us now consider a human analogy—the resident of a small town in rural America, perhaps in the more simple times of 40 years ago. Obviously, this selection of a scene is for the purpose of drawing useful contrasts and parallels. The person in question has a high degree of self-sufficiency. He has a garden and a cellar stocked with food. He has a well, his own outdoor plumbing, and his supply of fuel for heat and lighting. He disposes of his own trash and garbage.

His home range is small; he commonly gets to his work or wherever else he needs to go by walking. He has recognition relationships with most of the people of his community. Here he has feelings of security and comfort. There is, he says, no place like home. The high degree of independence of this individual becomes particularly evident under "emergency" conditions. He can ride out a winter blizzard with composure, and most of the dislocations that affect him can be met with his own efforts. He needs a minimum of public service.

I think we can make a further suggestive comparison with the situation of a dweller in one of our large cities. Passing over the social and economic enclaves that produce something akin to small-town conditions, I select an individual who probably is more representative. Wherever he lives, he is dependent on a wide range of public services. His food, water, fuel, and power are brought to him, and his wastes of every kind are taken away. His work is likely to be many miles removed. To fulfill a specialized function in his community, he must meet a rigid transportation schedule in getting to the place of employment and returning home daily. Likely enough, he passes through territory that is largely unexplored and unfamiliar, and he has continual contacts with individuals with whom he is unaquainted. He has lurking anxieties in dealing with a wide range of unpredictable situations. He may develop the social callouses and aggressive behavior frequently observed in the residents of large cities. In a measure, the city dweller has lost his identity in a social melange that is diffuse and uncertain.

This individual is dependent for many things. He is vulnerable to every kind of public emergency. A drought or power failure, a strike or riot, a heavy snow that ties up traffic, can immobilize him and jeopardize his security. In this aggregation of largely strange humanity, he finds many of his activities organized and regulated. In turn, he needs protection from his fellow men. In concentrations of people it is evident that aberrant and anti-social behavior must be dealt with. There are health hazards to be guarded against. It exemplifies the unusual adaptability of the human being that many can tolerate these essentially unnatural conditions reasonably well.

THE DENSITY DETERMINANT

Since all "higher" animals are socialized in some degree, a measure of association between individuals is beneficial. It follows that with the increase of numbers an optimum density is reached in terms of behavioral needs and available habitat resources. At still higher concentrations we see the development of competition for space and other necessities and the breakdown of normal social relationships.

The behavioral and logistic attrition that builds up can be described conveniently by the term "stress." Eco-social stress is an elusive phenomenon—difficult to define, analyze, and quantify. For good reasons, scientists have largely avoided this baffling universe of inquiry in their investigations of population mechanics and animal relationships, although the physiology of stress is somewhat better understood (see review by Thiessen, 1964). The physical and psychic well-being of the individual is tied closely to environmental conditions.

To appraise the nature of high-density stress in human society, we may review, for want of more appropriate terms, some of the findings of Alfred Korzybski, known for his innovations, several decades ago. in the field of general semantics. In a paper of 1943, largely drawn from three earlier sources, Korzybski explored the increase in complexity of functional relationships or problems as individuals are added to a managerial system. He cited the work of V.A. Graicunas, who calculated the growth of problems faced by a supervisor as assistants with related work were added to his responsibilities. Deriving an appropriate formula, Graicunas solved for the increasing relationships as follows:

Number of assistants or functions	Number of possible relationships
1	1
2	6
3	18
4	44
5	100
6	222
7	490
8	1,080
9	2,376
10	5,210

We need go no further than 10 in the series, since it illustrates beyond question that the addition of individuals or functions in this relatively simple organization gives rise to an exponential increase in relationships. "At the root of the problem," said Korzybski, "lies the significant fundamental difference in the *rate of growth* between arithmetical progression, which grows by addition, for example, 2, 4, 6, 8, 10, etc., and geometrical progression, which grows by multiplication, for example, 2, 4, 8, 16, 32, etc." He stated further, "My whole life work, and particularly since 1921, has been based on the *life implications* of this neglect to differentiate between the laws of growth of arithmetical and of geometrical progressions." In effect, he despaired that those who govern could find the wisdom and means to meet their proliferating managerial tasks satisfactorily.

It seems evident that concentrations of people and, more generally, the growth of nations, produce a vast complexity that expands out of proportion to the build-up of population density. If, for example, our present world of 3.5 billions doubles by the year 2000, it might be supposed that the problems of government and social affairs would be twice as great. This would indeed be sufficient unto the day, but such a concept probably falls far short of reality. If we use the scale of the Korzybski example, which seems a conservative comparison, we might assume that the complexity of relations among one billion people is represented by an index of one; then the figure for three billions would potentially be 18 and for 6 billions 222!

The build-up of stress undoubtedly takes place correspondingly. This phenomenon has not been measured or even dealt with theoretically. It is the resolution of many density-dependent tensions, competitions, stimulations, and interactions. It is a plexus of curves that rise exponentially with every increase in population. Potentially, the computer is ideally fitted to reveal how these many variables synergize, but programming anything but a simple model using highly "psychic" estimates is beyond present technology in the field.

THE ELUSIVE OPTIMUM

Americans are accustomed to thinking of mass production as a means of attaining efficiency and lowering the cost per unit. This clearly does not apply to human beings. As people multiply and concentrate, they require more protection and service of every kind, and they are correspondingly more costly.

Which raises significant questions about our present population level and the issues that spring up on every side. Is this great and burgeoning complexity related to our always-increasing costs of government, our deficits, our inadequacies in dealing with social problems—especially the rising rates of mental and psychosomatic disease and crime? Does it help to explain why municipalities and state governments find it progressively more difficult to collect enough taxes to carry out their commitments to education and other multiplying functions? *Adding more land to the tax base does not solve problems where it adds enough people to create a disproportionate demand for public expenditures.*

We may reflect also that the labor force is growing with the population—at a time of increasing industrial automation. We are committed to a policy of full employment, and surplus labor must be added to private and government payrolls. This contributes to the tax burden and the cost of goods and degrades the effects of technology as a means of raising living standards.

If population growth beyond an optimum begets problems that increase more rapidly than human numbers, it might be assumed that this only bespeaks the immaturity of our social and economic science—that in due time man and his computers will handle the problem and produce a high living standard despite the difficulties. To an extent, this undoubtedly is true. But whether management skills can overtake a problem that is growing geometrically, and especially whether it can be done in a degree and in time to be a relief to this generation and those immediately ahead is highly questionable.

It is evident that many of the high-density problems of humanity pertain especially to cities. Some 70 percent of the American people now live in cities of more than 50,000 and the proportion is increasing. This has relevance also to the common outlook for help to the "underdeveloped" two-thirds of the world. It is a common economic view that rural populations of these countries must be gathered into cities and their land given over to large-scale mechanized agriculture. It is assumed that industrialization in our image will bring them the blessings of modernity.

Even assuming a drastic Malthusian reduction of population in the next 20 years, as seems inevitable, one wonders whether governments of the countries in question can achieve a sophistication that could make such a change of life possible for their remaining citizens. In an important degree, we ourselves have fallen short in dealing with the challenge of complexity. The President's Council on Recreation and Natural Beauty remarked (1968) that "No major urban center in the world has yet demonstrated satisfactory ways to accommodate growth. In many areas expanding population is outrunning the readily available supply of food, water, and other basic resources and threatens to aggravate beyond solution the staggering problems of the new urban society."

The concept that industrialization can be the salvation of over-populated and impoverished peoples seems also to neglect the fact that our own system is based on an abundance of native and imported wealth. The inhabitants of North America—only 7 percent of humanity—are using about half the world's yield of basic resources. Sociologist Philip M. Hauser (1960) has stated that, at our standard of living, the total products of the world would support about half a billion people. This seems a dim outlook for the 3.5 billions now alive and those yet to come.

At a cost, Americans have shown little understanding or respect for the cultures of other peoples. It might become us, and avoid responsibility for further great errors in dealing with the developing nations, if we proceed slowly in overhauling their social and economic systems.

There appears to be unmistakable evidence that the world at large has passed the optimum level of population. It has been widely assumed that this does not apply to the United States; but the foregoing considerations seem to indicate that we should be diminishing our problems at the source rather than always trying to outrun them. As Hardin (1968) emphasizes, the population problem has no technical solution.

Perhaps the most widely evident sign of our overabundance is degradation of the environment. The technological "explosion"—terminology that suggests a consciousness of some of the exponentials involved—has been accompanied by a corresponding re-working of the face of the land. The widespread pollution of water and air, and the despoliation of natural beauty need no particular documentation here. The solid wastes to be disposed of now aggregate 4.5 pounds per person per day. Thermal modification of natural waters as a result of power production is doubling in 10 years. There is ample evidence that in North America we have exceeded the capacity of the biosphere to degrade and assimilate our wastes. Not only should we be making strenuous efforts to avoid further population increases, but real and rapid progress toward better standards of life probably must await the attaining of a negative birth rate.

OUR GROWTH OBSESSION

Nowhere in the state of nature do we find animals prospering so well, surviving in such large numbers, living so long, and reproducing so abundantly as when a population is expanding to fill a vacant environment. Of course, this is what happened in North America during the past 300 years. The white man displaced the Indian and took over his resources for use at a "higher" cultural level that could support many more people. It is perhaps understandable that modern Americans have developed an expansionist euphoria that attributes collective weal to the growth process itself, rather than to the availability of resources on which growth can take place. The "expanding economy" idea has passed from the stage of useful realism to one of economic dogma.

Two of the "easy" approaches to success in business and industry have become routine. First, we have assumed the right to pollute air, water, and land or to mutilate the scenery as a valid part of the profit-taking process. Secondly, and because we have always had it this way, it is assumed that every enterprise has the "right" to expand through continuous increases in customers—which takes place through additions to the population. The view that this process goes on indefinitely and that it holds the key to the "American dream" is behind the huge promotion now under way to "attract new industry" and build population in practically every community that can support more people through private or public development.

It needs to be understood clearly that human numbers do not grow in thin air. They are a response to the broadening of the resource base and the opening of vacant or sparsely occupied areas through developments that support new communities. This is one way in which population can be manipulated—by creating more centers of build-up or, in the other direction, by deliberately preserving our open spaces for less intensive uses. It seems evident that we have no public incentive to increase population, yet our planning is consistently in that direction.

One who reads the transactions of the Western Resources Conferences will learn that as of 1960 there were 22 billion dollars worth of water development projects for seventeen states in the files of the Bureau of Reclamation—plans that engineers considered "feasible." These are planned for construction by the year 2000 (see McGee, 1960; Schad, 1960). It is assumed that every river system must come under complete control, with the total water supply utilized to establish new agriculture, new industry, and more people (estimated at 25 million) in all of the "undeveloped" open space that can be found. There are enthusiastic promoters of this program in the Congress and, needless to say, in the local electorates involved. Plans for more "economic development" for other sections of the country are going forward accordingly.

I do not imply that all such enterprises are not in the public interest, but to make these far-reaching resource decisions, our representatives in the Congress must have access to every kind of information. They are frequently reminded that they represent the construction beneficiaries who move the earth and pour the concrete. But they likewise represent every taxpayer who supports the great works, with their wonderful and baffling cost-benefit ratios. The harried Congressman must be the dependence of people at large who make use of space, scenic, and recreational features of this land—people who have little concept of what is happening. They know only that we are dedicated to "progress." Where that progress leads, or what kind of world is being contrived they are never told. Has someone decided for them that we are to have no hinterland? Are there to be smokestacks in every wilderness, a smog over every countryside, the threat of extinction over every flowing stream?

There is another concept of resource management that sees our continent as a composite of environmental types, each with its own character and its particular contribution to the national scene. The latter presupposes that there are many and diverse ways to achieve a pleasant life and that various regions have much to offer in their existing features and natural assets.

The wild creatures of this earth have survived because each performs a useful function in a reasonably stable ecosystem. Any living thing that is too successful destroys the sources of its livelihood and disappears with the community on which it depends. Man's vast power play in using, if not inhabiting, nearly every environment on this planet could be self-defeating if he does not have the insight to impose his own controls and work for that necessary stability in his ecosystem.

The 1968 report of Congressman Daddario and his Subcommittee on Science, Research, and Development observed that ". . . the population explosion is fundamental to the requirement for environmental management. Population must come under control and be stabilized at some number which civilization can agree upon. Otherwise, the best use of natural resources will be inadequate and the apocalyptic forces of disease and famine will dominate the earth."

Stability and an "agreed-upon" population level are indeed worthy objectives in realistic planning for the future. This can not be a cookbook approach with flat rules and precise standards. Conditions in both space and time are too uncertain and variable. But in ecological perspective it is possible to appraise the direction of trends and influences. For now, a curb on birth rate by every acceptable means and a major reduction of the government-sponsored environmental onslaught are two requisites of the greatest urgency. It is heartening to see signs that these are getting attention in the Congress.

DEMANDS OF CRISIS

We have come to a threshhold in world and national affairs where there is immediate need to apply sophisticated, up-to-date thinking if we are to mitigate, rather than augment, the growing miseries of mankind. Around the earth, much that needs to be done is blocked by a massif of ignorance. However, it certainly is true that the wars of history have made greater personal demands on men of many countries than what must be asked of the world's people in the years ahead. The population issue does not brutalize the masses and inflict hardship on the innocent. It calls for an appeal to reason backed by all the skills social science can muster. In our own nation public acceptance of new ideas is of such great urgency that real resources need to be applied in bringing it about. Many of our old traditions, assumptions, and slogans need a searching review with open-minded willingness to innovate.

Most of us are all too aware of the unrest of the new generation of our citizenry. I make no case for those who march and protest with no real effort at problem solving. But we probably can ascribe some of their social malaise to the frustrating complexity of the world in which they find themselves—a world in which there is no reassuring guidance toward recognizable goals, no convincing reasons to assume that the individual has a defensible purpose in being.

There is, to be sure, an "establishment" devoted to high-sounding maxims that are supposed to be worthy and venerable by definition, but which seem to confuse rather than simplify our human problems. In the sum-total of their ecological malpractice, the elders are heading humanity toward the damnation of the lemmings. If youth does not see this at once, there are good reasons; for no one has given them any rational concept of man's relationship to the earth or any basic ethos of human respectability. In our overgrown institutions of higher education the husbandry of their intellects is monitored by humanists who are not biologists and biologists who are not humanists. They learn how to do great things but the why of nothing.

This is to identify one of our overshadowing difficulties. In this time of television, moon exploration, and the imminent availability of nearly unlimited sources of energy, it is obvious that accomplishments in engineering and its supporting sciences are awe-inspiring testimony to the capacity of the human mind.

Attending all our technical triumphs, however, is a growing realization that we have a critical area of weakness. While we know how to do fantastic things, we frequently do not know when and where—nor indeed why—to do them. The problem transfers itself from physical science in the development and use of hardware to another sphere in which we are less competent—that of the biology and ecology of man.

The nature and proportions of this problem actually bespeak the relative complexity of the systems of nature. Even though the physical characteristics of matter and energy are inconceivably involved, they are far less so than the limitless intricacies of the world of living things. Biological systems include all the variables of physical science plus the endless elaborations of more than two billion years of organic evolution. To the structure and physiology of the living organism are added the organization of ecosystems and the behavioral adaptations that are essential to survival.

In these dimensions were the origins of man, and now his culture has taken over to reorient his own speciation and vastly modify the habitat in which he developed. If, with the tools now at his disposal, he blunders unaware into the throes of overpopulation and environmental ruin, he could in a tick of the geological time clock be carried away to oblivion by the mechanical monster he has created.

Pessimism always has a hollow ring. But where so much is at stake there is more safety in planning for the worst than always hoping for the best. The truth is that today's greatest problems will not be solved. We are too late, and we failed for lack of foresight. Only tomorrow's problems can be solved, and only if we of today agree to be responsible for tomorrow.

LITERATURE CITED

Borgstrom, George
1965. The hungry planet. Collier, New York. 507 pp.

Daddario, Emilio Q. *et al.*
1968. Managing the environment. U. S. House Rep., Subcom. Science, Research and Dev. Rept. 59 pp.

Hardin, Garrett
1968. The tragedy of the commons. Science 162(3859): 1243-1248.

Hauser, Philip M.
1960. Population perspectives. Rutgers Univ. Press, New Brunswick, N. J. 183 pp.

Korzybski, Alfred
1943. Some non-Aristotelian data on efficiency for human adjustment. 2d Amer. Cong. Gen. Semantics, Pap. 541-548.

McGee, Gale W.
1960. Water resources developments for tomorrow. Western Resources Conf. 5-12.

Newman, Peter
1965. Malaria eradication and population growth. Univ. Michigan, School Publ. Health, Bur. Publ. Health Econ., Research Series 10.

Paddock, William and Paul Paddock
1967. Famine—1975. Little, Brown and Co., Boston. 276 pp.

President's Council on Recreation and Natural Beauty
1968. From sea to shining sea. Washington, D. C. 304 pp.
President's Science Advisory Committee
1967. The world food problem. The White House, Washington, D. C. 127 pp.
Schad, Theodore M.
1960. Water requirements and water policy. Western Resources Conf. 13-28.
Thiessen, D. D.
1964. Population density and behavior: a review of theoretical and physiological contributions. Texas Repts. Biol. Med. 22(2): 266-314.

DISCUSSION

CHAIRMAN STAHR: Dr. Allen, that was a strong, bold, and jolting talk. It is interesting to reflect that it takes a real radical these days to argue for stability. The clock is turned a long way around.

The time has now come, I believe, to introduce our Vice Chairman.

Our Vice Chairman is a journalist. He is an employee of a newspaper well known and highly respected around the world, a newspaper published in a great megalopolis but he himself tells me he was born a country boy in Ohio. He has been in Washington for the New York *Times* for the past ten years. I am happy to present Mr. William M. Blair, reporter for the New York *Times*.

MR. BLAIR: I could not help but think, when our speaker was dwelling upon the instability of this world, of the question: Are we rising to the level of our own importance? That is the first question that I would ask.

DR. ALLEN: I hope we will rise to new levels by applying our science to our most difficult problems, some of which I have alluded to. We have not brought our science to bear on these problems as yet. I think we know a great deal more than we have been willing to apply up to now. The trouble is that too small a minority of humanity knows these things. If a certain 10 percent of our people were killed overnight, we would lapse into savagery. I believe that and I know many others do also.

We believe in something that has been talked about for many years, and getting action is the big problem. We can rise above our incompetencies, if I interpret your question correctly, but I am not sure we are going to do it before we have even more painful illustrations of what our incompetence has done to us.

TO PRESERVE THE COUNTRYSIDE—BUILD NEW CITIES

WILLIAM E. FINLEY
Vice President for Community Development, The Rouse Company, Columbia, Maryland

It seems as if we city folks are greatly outnumbered today by those concerned with the places where cities aren't, and yet the title of the conference "Conservation in an Urbanizing Society" is clearly a recognition of the growing battle between our exploding cities, our oozing suburbs and our natural heritage. Even as you concentrate on the places where cities aren't, there has been a narrow view of cities today by those who attempt to guide their destiny.

The leaders and managers of American cities are so entangled in the problems of congestion, poverty, taxes, ugliness, suburban scatteration, and dwindling treasuries that they can almost not be concerned with the places where the cities aren't.

And those of you who are professionals in wildlife and natural resources can only look upon our cities and our enormous population growth as a threat to our most important national treasures.

The very fact of our being here together in this session is marked evidence that we both have a common concern for that growing conflict over the demand for use of open-space resources.

The basic thrust of my paper is to point out that by intelligent urban planning we can save for posterity those important elements of our natural landscape, in and around our cities, to the benefit of city and suburban people and in some ways reduce the pressure on the massive open spaces of the West and the all-too-few federal lands in the East.

There is agreement on all sides that our nation's population will increase from 200 million to 300 million by the year 2000, only 30 years from now, and that the lion's share of that growth will be at the periphery of our cities, in the style which they call in New York, "spread city." Like syrup poured on a table top, suburban development will continue to cover the land in a seemingly endless checkerboard of largely unrelated development. People will live farther and farther from downtown, social pressures will be kept on the central city, businesses will flee to the suburbs, thereby decreasing the value of the central city and further encouraging suburban development.

In this helter skelter of land speculation and development relatively little open space will be preserved. Sites for public facilities will most often *not* be set aside. Highways will get wider, transit more uneconomic, and the social disparities in our metropolitan areas will become even more severe than they are today.

But worse than that, the next 100 million people will not be the last 100 million. The next 100 million will use only 2 percent to 3 percent of the nation's land as a resource. Today's 200 million, now only cover 1 percent. Sometimes people act as if the nation is going to cease to exist or growth after the year 2000. While it is only natural to be concerned with only the generation ahead, from a personal point of view, those of us who are students of cities and resource professionals must always be thinking beyond the next generation.

At this point, the places that worry me the most are those that are close in to our exploding metropolitan areas, the seashores, the rolling farming countryside, the forests, and the inadequate parks. They will be overcrowded and their basic values can be destroyed by too intensive use or even development itself. I have the impression that public programs, especially state and local, are not keeping up with urbanization. The problem is more critical in the East and Middle West where half the population now lives but where there is located only 4 or 5 percent of the federal public lands with their park and recreation potential. While recent federal open space legislation has tipped its hat toward federal assistance to state and local governments, so far it has been too little and too late. What kind of a nation are we where the Federal Government builds highways on a 90-10 formula but supports only 50- 50 for acquisition and preservation of the countryside?

There are real values for people in saving some of the countryside. It obviously is the place where one can have contrasting emotional experiences, a place to be alone, or a place for families or lovers to walk. Somewhere in the spirit of all people, and especially Americans, is a deep love and respect for the forests, the lakes, the mountain tops, of places for low-pressure, low-density recreation, for the witnessing of wildlife and wild flowers. And those farms and fields which represent the agricultural base of history of our nation.

But what a battle it takes to buy new lands for national parks, to save The Dunes, Point Reyes, and the Cape Cod seashore! These most recent cases are places where the growth of population threatened their very existence and only with enormous cost were they purchased, to be held in trust for the nation. This seems an expensive way to preserve land.

Earlier I mentioned that most of tomorrow's growth would be incremental to the cities and towns of today. But I would propose that there are other alternatives which are healthier for our people from many points of view. I would submit cities which have reached a scale of from 5 million to 10 million people are almost to the point of being beyond livability. As we have all watched New York in the last twenty years, it is obvious that it is a city and region almost beyond management and certainly beyond a joyful way of life for anyone less than the rich.

And should Chicago and Philadelphia and Los Angeles and the Bay area and Baltimore and Washington all grow beyond 5,000,000 to 10,000,000, then what, after the year 2000? Is it possible for these cities and regions to ever catch up in transportation, housing, urban renewal, the rebuilding of schools and other facilities? I read that the percentage of pollution in the air is reaching danger levels in several metropolitan areas and every thousand automobiles and chimneys added to the area further menace the public health.

Therefore, we must come to what seems to be an obvious other choice and that is the building of *new cities* beyond commuting distance frm those which exist today. Not new towns, *à la* Britain and Scandinavia, which would also be "too little and too late" for a nation as giant as ours, *but whole new major cities of a million people or more*. Cities designed and built by using what we know today about the problems of cities and the new methods available to create a way of life which will make people's existence on this earth creative and rewarding.

As one who is involved in city planning and for the past six years in the building of a small new city, I am absolutely sure that we have the knowledge, the insight, and the resources to build dozens of new cities across the nation in the last generation of this century.

We only need to apply what we know about human values and the systems for human existence in the fields of education, recreation, transportation, housing, employment and conservation. We know how to design better neighborhoods which are safe and pleasant, have variety, enhance the life of children and parents and young people and old people. We know how to design and build places for meeting and schooling and shopping and participation in the arts, and all forms of social and creative activity. And we know how to build downtowns and great industrial centers, and to design methods of transportation and communication which enhance our lives rather than throttle them. We have a start on the management capacity, to locate, plan, design, construct and manage new cities. However, I believe it can only be done with careful combination of public power and private means. It can only be built by free enterprise in a public framework within which each of the components of our economy and society can play complementary roles.

The designation of locations for urban centers is an act that can create enormous values to be appropriately shared by the public and the private enterpreneurs necessary to carry out the program of building new cities. The very values created can pay for the public investment in advance funds for land acquisition, planning, and for building the infra-structure of highways, utilities and community facilities necessary to create the framework within which public and private resources can go to work to create these new places.

They will probably have to be created by local, state, or regional development agencies. They should be similar in function to an urban renewal agency in the city or county, have the power of acquisition and responsibility for planning, and the disposition of land for public and private purchase. It is likely that federal, long-term, below market interest loans will be necessary to prompt and assist these development agencies to move, to designate locations, to acquire them, to plan them and carry out their orderly disposition. And in the process, adequate amounts of the countryside can be preserved.

All this implies a strategy not of controlling the growth of cities (which has proved unworkable even in a totalitarian society like the Soviet Union where they have been unable to limit the growth of Moscow). The principle here is one of *diversion,* of changing the magnets of growth. I believe that people, industries, and institutions are willing to move to new locations, to atmospheres of innovation and safety. I am absolutely satisfied that such new cities can be built.

Twenty miles from here, in our new city of Columbia, Maryland, you will find living proof that a new environment can be created and that people and jobs and institutions will flock to it. As an alternate to suburban sprawl, and to show what energetic entrepreneurs could do in creating a better life environment for our Company, a relatively small real estate finance and development organization, teamed with an imaginative life insurance company, Connecticut General, and acquired privately 15,000 acres of land, in 176 purchases at a cost of nearly $24,000,000. We have invested $30,000,000 into the improvements necessary to make it a place where home builders and buyers, where apartment dwellers, and new industries, colleges, a symphony orchestra, shop keepers, artists, young people and old can move to experience a new way of life.

Columbia is being built in a county that has been basically rural, midway between Baltimore and Washington. The county government in charge of schools, police, fire, and basic utilities has shown a remarkable willingness to proceed. Our plan, submitted for their approval, accommodated the widest spectrum of housing and income, of industry and service, of cultural, recreation and entertainment places, and preserves 25 percent of all the land as permanent open space. The circulation systems of pathways and underpasses to high-speed arterials and a public transportation system all knit together the fabric of the community.

In the Maryland countryside we are creating a city of 150,000 people, a small effort in the national scene to be sure, but a pioneering effort to show the way. With Columbia and some other new towns as guidance, our nation certainly can move in the direction of preserving its natural inheritance by building new cities which, in turn, will slow the rate of growth of our existing cities. Only then will there be enough open countryside available to our growing population. With that available to meet much of the recreation demand, the pressure on national parks, state parks, and wilderness areas can be reduced.

DISCUSSION

DR. ALFRED D. GEIS: As I understand it, you said that cities like Columbia are actually adding to the present urban sprawl rather than solving it. Therefore, would it not be better to solve the problem of the central city rather than to try to add new problems by creating these types of communities?

MR. FINLEY: You are only partially right. I think it is fair to say that a small private venture, like a Columbia, has to be located initially in the economic watershed of a growing metropolitan area. At the moment, in the absence of any national, state or regional policies controlling industrial location, it is unlikely that a new city can be created in the boondocks beyond commuting distance. Only with national, state and regional policies can we build new cities in the locations that I recommend. I do not think that small new cities, such as Columbia and Reston, add to the problem. What they do is to coagulate, to gather together growth that would ordinarily spread over a much wider area because of their higher densities and concentration.

However, I don't think they are the whole solution to the larger national problem.

Further, there is money to be made by public agencies in capturing values that are involved at the new city locations. I don't mean that central city rebuilding should wait. But there are many industries and many families who cannot locate in the central city. Of equal importance are the rebuilding of central cities and the building of new ones.

DR. J. J. SHOMON (National Audubon Society): Your plan to hold 25 percent of the land in open space is certainly encouraging. What worries those of us in open-space preservation is the permanency and proper maintenance of this open space. What kind of built-in assurance can you recommend that this permanent 25 percent open space will be properly preserved and maintained?

One big problem we face today in our cities and in a lot of surburban areas is the terrible mismanagement, neglect, and poor maintenance, of the open space that we have. How do you hope to face that problem in Columbia and how would you suggest others face it in new cities?

MR. FINLEY: We are very much concerned with this question in planning Columbia. We found ourselves in a rural county with no park or recreation program, with relatively little concern for open space because, of course, most of the county was open space. They had a little saying in Howard County, for example, that when you purchased a quarter of an acre, you received a deed to the county, which means that everybody was used to looking out their picture window at their neighbor's farm.

What we have done is to create a perpetual easement of the open-space land which cannot be removed. This is a private and voluntary action on our part. We then, in turn, deed the land without charge to a permanent non-profit organization, which is, in turn, supported by assessments on all the developed portions of the land—in effect, a private tax. Among its more important charges is the permanent ownership and maintenance of these open spaces. We have made the system as tight as any lawyers in the country can make it, and we are satisfied it will work.

MR. BLAIR: Are there other comments? If not, I again turn it back to your Chairman.

CHAIRMAN STAHR: This leads us to our next subject. At the opening session, after Mr. Brooks and others had discussed the crisis of the clean environment problem, a pointed question was raised whether our political machinery was adequate to deal with environmental problems. The question was inadequately answered and possibly cannot be adequately answered. However, the subject of the next speaker is a partial answer.

FRESH APPROACHES FOR GOVERNMENT ORGANIZATION

LYNTON K. CALDWELL
Professor of Government, Indiana University, Bloomington

Governments are organized for the purpose of implementing policy. The ultimate purpose of a specific organizational proposal may not always be made explicit by its advocates, but there is a purpose nevertheless. The substantive purpose and effect of organization measures have significance beyond qualitative values such as efficiency and economy that pertain to the way the tasks of government are performed, but tell nothing of the purpose or worth of those tasks. The following remarks are intended to deal primarily with questions of government organization—not policy. But because policy implementation is the only reason for a discussion of organization within the context of this paper, its beginning and its ending will relate it to the policy issue that is involved.

The issue, stated as a question is this: Do the welfare and safety of the American people and the conditions of their future happiness and prosperity require that the Government of the United States commit itself to explicit responsibility for the protection and enhancement of the life-support base—the environment—of American society? Some Americans may find it hard to believe that their government has no such explicit responsibility. It may indeed be implicit in more than one Constitutional provision, and it can easily be construed as consistent with the purposes set forth in the Preamble. But the Congress of the United States has not yet adopted explicitly a general policy to protect and improve the quality of the American environment and to determine in principle the degree of priority that this policy should have in relation to other policies that might conflict with it. Fresh approaches for government organization in relation to environmental policy are being called for today by those Americans who believe that the United States must on behalf of its people adopt and implement a positive and coherent policy for the conservation and management not merely of natural resources in the conventional sense, but of the total environment in which men live, work, and shape the growth of civilization.

Although few events seem more improbable than governmental reorganization, it is clear, in retrospect, that governmental structure does change. The organizations of the Congress and of the Executive Branch of the Government of the United States were not intended for the conservation and management of the human environment. Their structures are poorly adapted to this purpose. Even with a poor structure for the conservation of the environment, it would be possible to implement a comprehensive national policy if the efforts in the White House and the Congress were sufficiently determined, vigorous, and unremitting to obtain the adoption of such a policy. But the task too often would require the pushing of public policy against the grain of the administrative system in the Executive Branch and the committee structure in the Congress.

ORGANIZATION AND THE CONGRESS

The jurisdiction of Congressional committees is divided in a manner that would appear to prevent any comprehensive review of environmental policy short of action by the committee of the whole when a bill is up for passage. At the present stage of policy-formulation, a lead has been taken in the Senate by the Committee on Interior and Insular Affairs and in the House of Representatives by the Committee on Science and Astronautics. The House Committee on Interior and Insular Affairs has followed a more conservative course, but its chairman has been an active proponent of the work of the Public Land Law Review Commission. However, if and when actual legislative action becomes imminent, it is possible that other committees will assert their jurisdiction on specific matters. Probably no single committee can be organized to deal with all aspects of environmental policy. But it would not be difficult to suggest a more efficient arrangement than the one presently in effect, if the Congress is to play a constructive role in the shaping of environmental policy.

There is resistance in the Congress, and with good reason, to the creation of new committees. It is obviously difficult to abolish or consolidate old committees with resulting loss of chairmanships and other committee prerogatives. Nevertheless, either a joint committee on the environment and natural resources or corresponding committees in each house that could meet in joint session would afford a more coherent organization for policy formulation and review than we have at present. But equally, and perhaps even more, important than this change would be to redefine the jurisdictions of committees—such as those having to do with public works—so that decisions vitally affecting the quality of the environment could not be taken unilaterally by committees with no official concern for the environment as such.

A major argument in favor of joint or dual Congressional committees on the environment and natural resources would be to enable the Congress to play an effective role in relation to the Executive. Several bills creating (under various names) a council on the environment were introduced into the 90th Congress and have been reintroduced into the 91st. These proposals would establish a council, to be situated in the Executive Office of the President—its status and powers to be similar to those enjoyed by the Council of Economic Advisers. Under most of these proposals the President would periodically transmit to the Congress a message on the state of the environment. As the Congress is presently organized, the content of such a message would be divided in referral to several different Congressional committees. Some competition among Congressional committees is not a bad thing for public policy. It is insurance against committee misfeasance or non-feasance. Nevertheless a clearer fixation of Congressional responsibility would be desirable in developing public policies for conservation and the environment. Joint or dual committees would be logical recipients of the Presidential message, as they would have the power to act upon it or to initiate legislative proposals on a broad range of environmental policy issues. The need for this restructuring in the Congress will become clearer when considered in relation to the reorganization of the Executive Branch from which policy proposals are transmitted to the Congress.

THE EXECUTIVE BRANCH

If the United States is to cope effectively with its major environmental problems, some restructuring of the Executive Branch seems necessary. The reason for this necessity should be clear; the present organization of government was put together piece-by-piece in response to popular demand for public assistance in preempting and exploiting the natural resources of the continent. Many laws and missions administered by federal agencies are of dubious relevance or utility to American society as it is today. An urbanized, mobile, science-using, highly productive, and affluent society finds new values and goals in the environment replacing and often conflicting with the values and goals that the present structure of government was built to serve. The dominant purpose of the various proposals for governmental reorganization that have been made has been to establish the care and custody of the natural environment of the nation as a public responsibility and trust superior to the special interests of resource development groups that the present organization primarily serves. Three distinctive innovations in the organization of the federal Executive Branch have been proposed. Each of the three have been modified and interpreted in various degrees, and none is really mutually exclusive. In the order of the extensiveness of the changes that they would introduce they are: *first*, an assistant to the President for liason with the natural resources and environmental management agencies and programs; *second*, a high-level Council on the Environment, for surveillance, review, and reporting functions and; *third*, a cabinet level Department of Environment and Natural Resources, absorbing nearly all of the present functions of the Department of the Interior, most of those performed by the Department of Agriculture, and some now housed in the Departments of Commerce, Defense, and Health, Education and Welfare.

The liaison officer is the most modest of the proposed innovations, involving no real organizational change in the Executive branch and requiring no Congressional action. This presidential appointee would work with and might act as executive secretary for a Council on the Environment which might be formed out of the present inter-agency Council on Recreation and Natural Beauty. These measures were reported by the *New York Times* on January 14th to be among the principal recommendations of President Nixon's pre-inaugural Task Force on Resources and the Environment. They could mark the beginning of a new orientation in federal policy toward the environment even though it is doubtful whether they would have any dramatic immediate effect upon federal action. A presidential special assistant for environmental affairs could be a pathetic and ineffectual figure if the President did not provide strong purposive backing for an environmental policy of some kind. And inter-agency committees and councils are by definition creatures of compromise and mutual accommodation. In short the recommendations attributed to the Nixon task force would appear to be constructive and might result in some positive accomplishment. They would hardly qualify as "fresh measures for government organization," nor were they probably intended to do so.

The second innovative proposal that has been under discussion is not really new as a proposition. The idea of a high-level board of review on resource and environmental issues was considered by the Hoover Commission Task Force on Natural Resources and was, in effect, proposed to President Kennedy by the National Academy of Sciences Committee on Natural Resources. This council is distinguishable from that allegedly proposed by the Nixon task force in its membership, independent of existing federal agencies and programs. This is a very important difference as the "independent" council would presumably view existing federal policies and programs "from the outside" and its members would not be spokesmen or representatives of the federal agencies.

In order to understand the purpose and role of an "independent" environmental council at the highest levels of policy formation the following factors should be recognized. ***First***, to be effective the council must have the approval and confidence of the President. The proposals introduced as bills into the 90th Congress, and into the 91st Congress thus far, have represented congressional rather than presidential initiative. The Johnson Administration was not known to have taken a position for or against these proposals and none of them reached a stage of public hearing. Unofficial opinion in the agencies most closely affected by the proposals—the Bureau of the Budget, the Council of Economic Advisers and the Office of Science and Technology—appears to have been mixed. It might be assumed however that representatives of the existing advisory structure would not extend on enthusiastic welcome to a new member of the Executive household where arrival would necessitate some redefining of their own jurisdiction and relationship. In advance of an actual presidential request for opinions from the present advisory agencies with regard to a specific proposal for an environmental council, it would be impolitic to pre-judge the agency response. But it would not be unfair to observe that the almost invariable response of existing agencies to proposals of the type under consideration tends to be negative.

On the desirability of an environmental council the President must, therefore, form his own opinion independently of the existing official advisory structure. The response of the great federal departments and commissions could also be expected to be less than enthusiastic. This is because a major function of the council under the various proposals in the Congress would be the coordination and reconciliation of agency policy and action. It is a safe generalization that no autonomous agency or administrator welcomes "coordination" from the outside—even in the public interest. The proposed council would not itself undertake to coordinate agency action, but its studies, hearings and reports would be a force for coordination under the authority of the President. Most importantly, it would not be dependent upon the concurrence of the federal agencies in the formulation of its findings and recommendations.

The high-level advisory and review functions of the council would necessitate the location at the presidential rather than at the departmental level. It would be as logical to locate the Council of Economic Advisers in the Department of the Treasury as to attach the council on the environment to a Department of the Environment and Natural Resources. Even though the principal federal agencies engaged in environmental management were brought into a large new coordinative department, there would (and probably should) remain many environment-related programs and activities in other departments. A council that was responsible for the review of national policy generally, and for surveillance of the activities of all federal agencies and departments in relation to that policy could be situated at any level lower than that of the President or the Congress.

It would, of course, be possible to relate a council on the environment to the Congress instead of to the President. Its status might resemble that of the General Accounting Office, the Civil Service Commission or the Technology Assessment Board proposed by Representative Emilio Q. Daddario. Should the magnitude and complexity of governmental operations push the nation away from the absolute primacy of the President and toward greater responsibility at the cabinet level, this "independent" status might prove as effective as location in the Executive Office. The advantage of this status is that the Congress would be more closely involved in the responsibility for environmental policy-making. Moreover, if the Congress should be more responsive than the President to public demand for an environmental policy, the Congress could move ahead to create the council and adopt a national policy without waiting for presidential initiative.

The effectiveness of national policy is greatest when both the President and the Congress are in concurrence. Whether a council for the environment is established within the Executive Office or whether it is either a joint agency or is responsible primarily to the Congress is less important than its high-level status. In essence, its functions as suggested by recent legislative proposals would be four: goal proposing, surveillance, analysis, and reporting. The council, through its own staff, and through government agencies, universities and research institutes, would monitor the state of the environment. It would measure a variety of environmental conditions against standards set by scientific and governmental authorities and, after analyzing the data and ascertaining their meaning, would report its findings to the President, to the Congress, and to the American people. Whether, and on what conditions, the council might report directly to the people instead of to or through either of the constitutional branches would depend upon its legal status. If established as advisory specifically to either the President or to the Congress, it might be inappropriate and perhaps even illegal for it to report directly to other than its sponsor. One of its most useful functions in any case would be to help the President, the Congress, and the American people to consider alternatives, to set priorities, and to formulate goals for management of the nation's natural resources and its environment.

The bills in the 90th Congress indicated the Executive Office of the President as the location of the council, and they required the

President annually or biennially to report to the Congress on the state of the environment. As previously noted in this paper, the President's report would normally be referred to the committee or committees primarily concerned with its findings or recommendations. The present assignment of committee responsibilities in the Congress is not well adapted to a consideration of broad environmental policies. Environmental issues are certain to grow in importance and urgency relative to many public questions that have hitherto enjoyed higher priority among Congressmen. The restructuring of several of the existing committees to form a joint committee on the environment would seem therefore to be a logical and perhaps a necessary corollary to the high-level council on the environment and the President's message to the Congress.

The restructuring of the executive agencies for greater environmental policy effectiveness presents a complex challenge. Alternative possibilities are numerous. Any major change in relationships among existing administrative units across departmental lines has implications for the structure of the entire Executive Branch. This is not necessarily a deterring factor to consideration of a major organizational change, for in any event a major restructuring of the Executive Branch is becoming necessary for operational and coordinative reasons. Therefore, although the nation has historically preferred single-purpose and *ad hoc* measures to comprehensive reorganization plans, it would be wise at this stage in American history to reorganize for environmental policy as a part of or in relation to, a more comprehensive and fundamental rethinking of the functions and responsibilities of the Federal Government and the respective responsibilities of the President and the heads of the great federal agencies in the formation and administration of public policy.

Regardless of constitutional theory, the practical responsibilities of the President must increasingly be shared with the heads of the major administrative agencies. This sharing of responsibility means a sharing of power, and, if the power is to be shared responsibly, the top level of executive authority must be clarified and simplified. Ultimate decisions on controversial questions remain with the President. But no human personality can possibly fulfill the extravagant demands upon presidential leadership that have increasingly been made since the beginning of the 20th century. In the 1930's the Executive Office of the President was established to give the President help. But, with the exception of the Department of Defense, and certain detailed reforms initiated by the Hoover Commission, the enormous increase in the magnitude and complexity of federal operations during the succeeding decades has not been accommodated by more than incremental changes in administrative structure. New agencies such as the Atomic Energy Commission and the National Space and Aeronautics Administration have complicated rather than assisted in the administration of national policy at the presidential level.

Simplistic solutions may not provide good answers to complex problems. At the highest level of policy determination, however, unnecessary complexity and diffusion of jurisdiction defeats the objective of public understanding or the accountability of government to the people. The President cannot reasonably be expected to decide personally on more than a relatively small percentage of policy questions cutting across agency lines. As a consequence, issues are often determined by staff in the Bureau of the Budget, or by members of inter-agency committees who have no public visibility and of whom the public or even the Congress has no real knowledge. The inadequacy of the federal administrative system for resolving policy differences below the presidential level has been amply demonstrated. Coordination of natural resources and environmental policies has fallen far short of need because of the inflexible mission-orientation of many agencies, the lack of an adequate policy basis for accommodation, and the frequent absence of any responsible court of appeal in disputed cases short of the President himself.

Of special relevance to the administration of environmental policy would be a plan to alleviate the coordinative role of the President by reducing the number, and upgrading the status, of cabinet level departments. A cabinet of from seven to nine super-departments organized around major national responsibilities could provide a manageable and more coherent extension of presidential power than the present structure which is especially diffused and inchoate for purposes of environmental policy. Among the new enlarged cabinet-level agencies, a department for the environment and natural resources could be established.

This alternative would bring most of the present Departments of Agriculture and Interior together into the new super-department to which would be added agencies presently within the Department of Commerce (Environmental Sciences Services Administration), the Department of Health, Education and Welfare (air pollution and solid waste activities), and the Department of the Army (civil functions of the Corps of Engineers). A new unit, the Water Resources Service, would combine inter-related activities now administered by the Bureau of Reclamation, the Corps of Engineers, the Soil Conservation Service and the Water Resources Councils. If energy is to be treated primarily as a natural resource, it would be logical to bring such independent agencies as the Atomic Energy

Commission and the Federal Power Commission into the new combination. It would also be desirable for this new cabinet-level agency to be called the Department of the Environment and Natural Resources or Department of the Environment, Natural Resources, and Energy to emphasize its responsibility for the protection and improvement of the environment as well as its concern with natural resources, especially those resources concerned with energy.

Several points concerning this so-called super-department should be made clear. ***First***, it is not likely to come into existence apart from a general reorganization of the Executive Branch. *Second,* its functions would be those of policy analysis, planning, and coordination rather than of management or operations. In this respect, it would resemble, in principle, the Department of Defense in contrast to the three operational departments under DOD's general coordinative jurisdiction. The super-departments should not be called departments; for they do not correspond to the meaning heretofore associated with this term in Washington. They correspond, in fact, to what are called "ministries" in many other political systems. But perhaps we Americans still nourish a prejudice against this term, inherited from the days of colonial antipathy to the ministries of the English monarchy. ***Third***, the super-department is no panacea. Yet a much better arrangement for coordinating and interrelating national policy for natural resources and the environment could be obtained under the super-department and still provide opportunity for appropirate competition among agencies. Most of the objections to the super-department idea have been raised in opposition to the DOD. Some of these objections are valid—every solution to an organizational change cannot be effective. It must be accompanied by concomitant changes in legislative authorizations, budget and appropriations procedures, policy clarification and staff reorientation. The fundamental question is *not* whether a radical change such as the super-department implies is politically feasible. If it is not feasible, it is because the nation is not yet ready to take seriously its worsening environmental situation. The fundamental question is what do we as a nation propose to do about the present and future state of our environment. The half-measures now seriously considered for environmental administration will serve the half-hearted efforts that we are now making to salvage and safeguard our heritage in nature. If we, as a people, had the vision to see what must be done if the present quality of life in America is to be maintained (or possibly improved) the proposed organizational changes in the Congress and the Executive Branch, which have just been described, would not be viewed as visionary.

The maladaptation of the present structure of the Executive Branch for present and emerging environmental needs is a consequence of swift and far-reaching changes in American society. During the first century and a half of our national history, the role of government in relation to the environment was to open the country to economic development. To this era belongs such activities as Indian removal, railroad grants, river and harbor improvements, irrigation, the promotion of agricultural settlement, waterpower and the exploitation of mines and forests. Early in the 20th century, the conservation movement arose in reaction to the profligate use and destruction of natural resources. By mid-century, however, this movement had evolved into a more fundamental effort for safeguarding the total environment and, where possible, restoring its damaged properties. President Lyndon B. Johnson identified this new level of public concern when in this message to the Congress on natural beauty (February 8, 1965) he declared: "Our conservation must be not just the classic conservation of protection and development, but a creative conservation of restoration and innovation. Its concern is not with nature alone, but with the total relation between man and the world around him. Its object is not just man's welfare but the dignity of man's spirit."

The idea of government as protector and manager of the environment in the interest of all of the people is a relatively recent concept. It is only now beginning to be understood and accepted. Important development tasks in the traditional sense will continue to require national attention. But the major public responsibility for the environment in the future must be the coherent management of its ecological-economic-esthetic and engineering aspects, with regard for its essential unity and in relation to the total range of human needs that the environment serves. A major task of reorganization therefore involves the reprogramming of those missions specified for federal agencies that are no longer of first priority relative to national needs. Legacies from an earlier era, they are locked into the law, the Congressional committee structure, the national budget, and the expectations of influential client groups at state and local levels. Many of the agencies engaged in transforming a frontier and agrarian nation into an industrial society could be reoriented so that their institutional experience and personnel could be applied to meeting the needs that all Americans now share. But it will take a very positive, persuasive, and imaginative effort to bring the personnel of these agencies to see this. Nevertheless, there are hopeful signs that in some agencies of the Federal Government this task of reorientation is already being initiated by far-sighted leadership within the agencies themselves.

IMPLICATIONS FOR LOCAL GOVERNMENT AND PARTY POLITICS

I would not be so foolish as to argue that these more radical changes in the Executive Branch must be made or that, if made, they will necessarily be undertaken in the 91st Congress or by the Nixon Administration. But I believe the trend to be in this direction. The trend is neither toward centralization nor decentralization of authority or decision-making. Trends move in both directions for different purposes. In relation to the personal role of the President there would be decentralization; in relation to naturally interrelating programs of separate federal agencies there would be greater policy centralization. And these actions, intended to clarify and strengthen federal policy for the environment are a necessary prelude to any really effective decentralization of responsibility to state, inter-state, or regional authority. The ability of the Federal Government to strengthen, support and cooperate with action at state and local levels would be advanced by greater clarity of purpose and coherence of policy at the federal level. The jurisdiction and the fiscal resources to deal with the major environmental problems of the nation are in the possession of the National Government. It is for this reason that concern for the state of the American environment should focus first upon the national level of policy and administration. Unless the National Government establishes a policy and provides national leadership for the protection and improvement of the environment, the governments of the states and localities cannot act with more than partial effectiveness. And it seeems certain that American public opinion will demand better performance on environmental protection from all levels of government.

DISCUSSION

MR. BLAIR: Before opening it to the floor, I would like to ask a question of Professor Caldwell.

It occurs to some of us who labor in the jungles of Washington that we always start at the top in our reorganization efforts. Is there any low-level governmental reorganization that may be needed in this field of human environment?

DR. CALDWELL: You have to start at both ends. When I speak of reorganization, I do not mean the mere reshuffling of the location of bureaus. This is not likely to accomplish much. The bureaus will still go on doing business as they have been doing it.

You have to have reorganization that gets down to the specific missions of the agencies. However, the reason we must concern ourselves particularly with the superstructure is that, to a large extent, what can and will be done at the grass roots depends upon the way policies are set and funded in Washington. There is much we can do to encourage, through appropriate national action, responses on the part of states and localities, and I don't underestimate the need for effective work at that level. However, in the time available it seemed wiser simply to speak to the federal side of this issue.

MR. WALTER B. SMALLEY (Washington, D.C.): The population problem can only be solved with food. The place we are going to get this food from is from the sea. I would like to have you comment on this aspect, if you will.

CHAIRMAN STAHR: The human population will expand as long as it has a resource base on which to expand. If we were to unlock vast and unlimited sources of food, I think it would be the greatest disaster the world has known, because more food permits more people to survive to breed more people to need more food and creates an even bigger problem for the future.

DR. CALDWELL: Food is not the problem except in parts of the world where currently there are threats of famine, but long before the human species gets to the point where it can no longer feed itself, it will have passed the point of toleration of the psychological and physiological stresses that have been referred to. We ought to disabuse ourselves of the thought right at the outset that food or shelter are the issues. It is not a question of how many people we can crowd onto the continents or of building platforms out on the ocean as some people suggest. Before we talk about that, we had better think a little bit about the social interactions. We would be very much misled if we felt food was the answer to the problem of unlimited population. It is a total ecological process we are concerned with here.

We are going to have to be very farsighted and wise to preserve as much personal freedom as we would like to preserve in the world ahead. But if we let the population run away as it is now doing, the amount of personal freedom anybody is going to have will be zero. You will probably have to live in essentially militarized states. The people who ought to be most aware and most concerned about this are those who believe in free enterprise in the market economy, because these are the first who will be eliminated when you have a totally regimented society.

CHAIRMAN STAHR: You know, I promised you a stimulating afternoon and I think we are producing it. However, time as well is an element and so we must go on to our next speaker.

BROADENING CONSERVATION'S CONSTITUENCY

MRS. DONALD E. CLUSEN
Second Vice President and Chairman, Water Resources Committee; League of Women Voters of the United States, Washington, D. C.

On behalf of the League of Women Voters I should like to congratulate you upon the choice of theme for your conference this year—"Conservation In An Urbanizing Society." This choice denotes a concern and an awareness of the fact that the problems of human resources and natural resources are inextricably interwoven. My organization shares this attitude with you and welcomes the dedicated conservationist as an ally in trying to find the means to cope with the monumental problems facing people and with the relationship of people to their physical environment.

The need and the dimensions of the resource crisis of the 1970's has been well documented and eloquently expressed during the past two days of this conference. It is altogether appropriate that this final session be devoted to the actions needed for the job ahead. The League is honored to have this opportunity to share with you our thoughts on how to broaden the base of those who seek solutions to conservation problems in an urban age.

BARRIERS TO ACCEPTANCE OF CONSERVATION'S CAUSE

It occurs to me that there is merit in attempting to identify the blocks which exist before trying to propose solutions. Therefore, I pose the basic question: Why haven't people in cities flocked to conservation's banner? Supported conservation causes in large numbers? Assisted in funding conservation needs enthusiastically? Applied the skill and knowledge of the conservationist to urban environments? I am sure there are many psychological and human factors involved in the response to this question, but in our few moments here together I should like to suggest three basic blocks to the acceptance of conservation's cause by urban leadership and to propose three basic remedies for these blocks.

To my mind, the first and most predominant block is lack of identification on the part of "city people" with conservation groups. Conservationists have somehow failed in semantics and in human contact with those who live in urban areas, failed to communicate real concern for their physical environment and their conservation problems. If you live in an over-populated area with little or no open space, few parks, only an occasional tree—if you are accustomed to the fumes which accompany city life, unable to swim in the closest river, it is difficult for you to relate these problems to the image which is evoked by the word "conservation." To the average urban dweller "conservation" means something which has to do with the Grand Canyon, the deer hunter, the fisherman, and the bird watcher but has little or no relevance to the city dweller and his daily problems of existing in a metropolis. If he thinks about these things at all, it is in terms of making his vacation plans or the amount of the tax dollar that is being spent to support camp grounds, clean up the oil slick off the California Coast, or build a dam in the West. It is something "out there," and those who are conservation adherents are, to him, for the most part, almost as alien as a man from outer space. It would never occur to the usual city resident, unless he has deep roots in the soil or an unusual concern for his environment, to seek out the local chapter of any of the numerous conservation groups in his area. The city dweller simply does not identify the word "conservationist" with himself nor the word "conservation" with his urban physical discomforts.

The second major block follows along the same line. In addition to lack of identification with conservation groups, the urbanite fails to identify his environmental problems as conservation problems. He knows he can't swim in the river at his doorstep because it is polluted—or catch fish in it—or go boating on it—but he fails to make the connection between this fact and the conservation groups which worked so hard during the setting of water quality standards last year. He knows the trees on his block are dying—or being removed to make way for a wider street or an urban renewal project—but he makes no connection between this loss of trees and the work of conservation groups with urban planners and city engineers and the state resource agency to save some greenery—some open space in the city. He knows that when it rains his newly-developed area is a sea of mud, his basement is flooded, his street impassible, but he doesn't think of this in terms of the work conservation groups have done in the establishment of building procedures to prevent soil erosion or to achieve comprehensive planning. The urban man does not regard any of these problems as conservation problems. He sees them as problems of city government, or the price of progress, or a fact of life with which he is so accustomed to co-exist that he ceases to see it at all.

The third block to vital growth in conservation groups from the urban segment is lack of awareness on the part of the latter of the aid, the expertise, the warmth, the helping hand—which is available to him from conservation interests, both public and private. Somehow in the barrage of words from conservationists, we have failed to convey the message that we care for people as well as trees; for the city as well as the country; for man as well as moose; for the city park as well as the national park. We have also failed to give high visibility and priority to the tools and the technology possessed by conservationists to remedy some of the ills of the city. We have not related well the know-how and willingness of conservation leaders to serve the cause of urban environmental problems—nor have we crossed the semantics barrier which exists.

There has been much debate in the past few years about the terms "conservation" and "preservation." To the uninitiated the meaning of either term and the distinction between them is cloudy. In the minds of city dwellers, the issue is no more resolved than it was in the last century. I personally prefer the definition of Dr. Raymond F. Dasmann, Director of Environmental Studies for the Conservation Foundation, who says, "Conservation is now defined as the rational use of the environment to achieve the highest quality of living for mankind." This definition has relevance to urban areas and sets forth a goal and a hope of a quality environment for urban as well as rural areas.

These three blocks, then, I see as the major problems—

—city dwellers don't identify with conservation groups
—city dwellers don't see their environmental problems as conservation problems
—city dwellers are unaware of the tools and the willingness of conservationists to assist them.

WAYS TO OVERCOME THESE BLOCKS

How to overcome these problems? I am going to propose in explicit and somewhat elementary terms some possibilities to you, because I believe that this is the point at which we must cease to be philosophical and be practical; this is the point at which we must stop being theoretical and become concrete.

First, conservationists must show a renewed interest in the people and the leaders and get to know those who live in the city. We must go to them—where they live—and speak their language. This power structure will not be the one with which we are accustomed to dealing, and it will not always be either pleasant or polite. There will be resistance and disbelief, apathy and a tendency to regard you as dreamers who live in an unreal world. You will need to seek out, at every opportunity, the leaders of urban groups, the spokesmen for the ghettos of the inner city, the heads of labor unions, the officials of city government. You will need to work to identify the people who are interested in the cities and the people who live in the cities. As in approaching any other new audience, you will need to make new contacts and learn about them in advance. What are their goals?

What motivates them? You will need to be prepared for rebuff, for you will be seeking out not conservation's natural allies—as we so often recommend—but its un-natural allies!

Urban dwellers do not automatically care about the same things as conservationists and so the burden of proof is on you—to commit yourselves for the long haul; to prove that you care what happens in the cities; to show that you are willing, indeed eager, to accept these citizens as co-workers and make their causes yours. You will need to work more intensively with the ward politician, the city planner, the urban renewal architect, the businessman's luncheon group, the community action boards.

The mantle of purity and the aura of pristine virtue which surrounds the concept of conservation in the minds of the man on the city street must be blown away. You will need to demonstrate graphically your willingness to identify with the city. An important principle of opinion-building—the identification principle—is involved. To accept an idea or a point of view, the people we are trying to reach must see clearly that it affects their personal desires, their hopes, or their interests. Identification has to do with self-interest. The problems which concern conservationists must be made meaningful to city people in ways that are observable and measurable from the point of view of their lives, in ways they will understand, in ways that will cause them to act.

How do we do this? Mainly it requires the ability to see things as others see them. We must project ourselves into the minds of other individuals or groups whose background and point of view may be quite different from our own. Such projection requires understanding and imagination, but you are imaginative people. Developing this ability to understand the attitudes and emotions of others will make the difference in bridging the communications gap which faces conservationists as they attempt to enlist city residents for their causes.

In order to further identify conservation groups with urban residents, we need to face the second block—that of helping these citizens to see their environmental problems as conservation problems and our goals as relevant to them. Perhaps the best way to achieve this is to try to bring it all closer to home. For example, those who live in the city do care where their children play, they do want to be able to find a green belt and some open space in or adjacent to the city proper. These are goals which they can understand and can identify with close to home, and it is with these immediate concerns that conservationists must cope if they are going to reach and motivate this wider base.

People do not buy ideas separated from action—either action by the sponsors of the idea or action which people themselves can take to prove the merit of any idea. Unless a means of action is provided, people tend to shrug off appeals to do things.

Another basic axiom is that people must be involved in the selection of the goal in order to care about its achievement. Therefore, it behooves us, in opening our dialogue with the city, to attempt to find out what not only the leaders but the people want in the regeneration of their city.

When you know what the people who live there want for their neighborhood, you will know how you can help them take some productive action to get it. One good case history of a small project in a major metropolitan area—a new park established or an old one saved—a place for walking, picnicking, relaxing, just beyond the city limits—a small waterfront area which offers brief respite from a bustling city—any of these things will do more to bring adherents to conservation from the ranks of the population of that city than thousands of acres added to a national park 2000 miles away.

The need is great for higher visibility to be given to the desire and the ability of conservationists to assist in achieving a quality environment in urban areas. We must devote as much thought, as much creativity, and commit as much personnel and funds to this end as to reaching citizens in other areas of American life. Conservation programs, publications, possibilities for action must be made a part of the program of every organized group in the city if the message is to be extended. A great deal more needs to be done through the schools, and children need to be reached at a much earlier age.

Young urban people will determine the environmental decisions of tomorrow. Their attention must be caught today.

Go to the schools, the news media, the power structure, the community organizations, the government in the cities and volunteer your group's ideas, personnel, and funds to help in rejuvenation of this nation's cities—for failure to do so leaves the ultimate resolution of these questions in the hands of people to whom conservation is only a word.

CONCLUSION

These then are the challenges and choices that I see for conservationists who want to broaden their constituency. The challenges: lack of identification of city residents with conservation groups, lack of relevancy of conservation issues to city problems, lack of awareness of what conservationists can and are willing to do to aid in rebuilding our cities. The choices: to show an interest in urban problems and to meet urban residents on their ground and speak their language; to bring conservation causes closer to home; to make available and to commit, with renewed vigor and open-mindedness, conservation's talents and money to these ends.

In our ultimate desire to preserve the future, we cannot afford to neglect the present. Entire generations grow with scarcely the existence of a green tree naturally grown or a cluster of wild flowers in a field. What dreams can we expect of eyes which have known only sooty concrete and steel? Evermore, urban man finds himself a particle of a metropolis but part of no community; alone against all the problems and nothingness a world beyond his ken has devised. And yet it need not be so. Never before in the history of the world has man possessed so much wealth and power, been master of so much technique and knowledge. It would truly be ironic if he could not bond all that experience and strength to the service of the preservation of his chosen home.

There is, in this room today, the imagination and the knowledge to lead the way to a new understanding of the relationship between conservation and the urban community. The continued survival of the new broader definition of conservation may very well depend upon how well the communication gap with this new constituency can be bridged. It deserves your best men and women, your greatest sense of purpose, your highest priority. Knowing you, I believe you will accept this challenge as you have so many others.

DISCUSSION

CHAIRMAN STAHR: Thank you for that excellent presentation.

In the spirit of the ecumenical approach to the problems of the conservation movement, I would like to invite all of you to come to St. Louis the last weekend in April, where a dialogue will be taken up again at the National Audubon Convention. All interested people are welcome.

I now give you a man who is spending more energy, thought, imagination, drive and effectiveness than one sees in connection with most conventions to make this the tremendously successful convention that it has been—Mr. Pink Gutermuth.

MR. C. R. GUTERMUTH (Wildlife Management Institute): Dr. Stahr, I want to thank you and all of the panelists, for your presentations, and all of you, for helping us out in this important matter today.

Now, we come to the final presentation, the appraisal of the Conference program, which is something that many people look forward to. To present this to you we have imposed upon a good friend, one of the leading and outstanding conservationists in this country—the president of the Resources For The Future in Washington, D.C., who will give us his views on this important international Conference—Dr. Joseph L. Fisher.

REFLECTIONS ON THE CONFERENCE THEME: CONSERVATION IN AN URBANIZING SOCIETY:

An Appraisal of the Program of the 34th North American Wildlife and National Resources Conference

JOSEPH L. FISHER
President, Resources for the Future, Inc., Washington, D. C.

Let's face it. To give you now an appraisal of the entire conference program—which is what the printed schedule of events calls for—is beyond me. By my count there have been 49 presentations thus far. With a good deal of huffing and puffing I might be able to relate these papers, each one interesting and important in its own right, to the central theme of the conference: *Conservation in an Urbanizing Society*. But I haven't the energy, time, or ingenuity to do it, and perhaps after three days in attendance at these meetings you would not have the patience to listen even if I tried.

But I do have a few major points on my mind. Above all, it is altogether a good sign that the North American Wildlife and Natural Resources Conference is devoting itself this year to the matter of conservation in an urbanizing society. The papers I have heard this afternoon, and others that I have read, are stimulating. This conference, I take it, is part and parcel of the increasing awareness that those primarily concerned with the rural and back country now have for the difficulties facing city people. After all, most of the hunters, fishermen and outdoor recreationists come from the cities, and most of the raw materials produced on farm, forest, grazing, and wildlands are destined to meet the demands of city folk. More than 70 percent of the people in the country now live in urban areas, and this proportion is growing steadily. Industrial plants are concentrated in the urban areas near to the people; the people and the plants together account for most of the wastes and pollutants which are dumped into lakes and streams, the atmosphere, and onto the land. In any list of important developments during the last few decades, urbanization has to be near the top. And from now on, I suspect, no significant program can be launched or decision made anywhere in the country without checking it out in terms of its relation to urban matters. But this is belaboring the obvious.

In an urban America that is becoming still more urban, here are some of the developments in concept and action that I think are needed if conservation is to reach its full stature. The needed developments I shall mention do not add up to a complete list, and I haven't time to develop them adequately. But what I am going to say will let you know how my thoughts are running. And I believe progress toward them will be helpful to the conservation cause and to our urbanizing society.

First, I think a clearer, more comprehensive statement of conservation goals will be helpful—a statement attuned to the highly urban situation in which the country finds itself. These goals will have to be stated in terms the urban dweller can understand: the hunting, fishing, and outdoor recreation possibilities available to him; the amount of money it will cost him to go to these places and enjoy these activities; the benefits of a clean and pleasant urban environment and what he will be required to do if this is to be achieved. Any new statement of conservation goals will have to put much more emphasis on environmental quality and natural beauty, in the urban as well as the rural setting, than has been given in earlier periods. For example, sustained yield as a goal for forestry is already being redefined so as to include a certain amount of wilderness preservation and much outdoor recreation, as well as timber production and water retention. Goals for soil conservation will have to deal with algae blooms in estuaries and lakes, caused by excessive runoff of phosphorous and nitrogen compounds contained in farm fertilizers, as well as with erosion of the soil particles themselves. But beyond this, the more traditional statements of goals in terms of forests, soil, water, and landscape need restatement, or reframing, in terms of human and social development goals. What role should conservation play in the reduction of poverty, the amelioration of racial conflict, the enhancement of clean cities, and the reduction of urban ugliness? What bridges can be built between what is called neighborhood conservation in cities and the kinds of outdoor resource conservation this annual conference typically deals with?

In my restatement of conservation goals there is no place for the "antipeople" viewpoint which many persons, rightly or wrongly, still attribute to the conservationist. Nor is there much room in my view for the scare approach—that the earth is about to be ruined utterly by additional billions of untidy, thoughtless people using up raw materials and messing up the landscape. I do not think people can be scared into good conservation; they must be educated and persuaded to it, and shown how it can be managed and reconciled with legitimate aspirations for a rising material level of living.

Second, I see a need for a broader, more inclusive, and more sophisticated concept of multiple use management of natural resources and natural resource areas so as to include urban factors. We conservationists have wasted a good deal of energy, intellectual and otherwise, in the fight between single-purpose and multiple-purpose use. We need to re-think the matter and draw a conceptual circle that takes both groups in. In natural areas of any size, we should expect a number of uses, but particular smaller parts of the area may be dedicated to single uses, or at least single uses at any one period of time. For example, in forest areas that I know quite well in Maine, Virginia, Colorado, Oregon, and Alaska, certain parts might well be preserved in an almost wild state, other parts along the margins of lakes and rivers could be wisely reserved for recreation, while extensive parts would be available for well-managed forestry operations. The challenge is to plan the use and management of natural areas so that different parts may be used for those purposes of highest economic and social value, in some instances with a variety of uses pursued simultaneously and in others with uses pursued in sequence. The single-purpose vs. multiple-purpose conflict tends to erode when viewed in this light. The time clearly has arrived when all natural areas will have to be managed, not only for timber production, livestock, agriculture, and outdoor recreation, but also for wilderness preservation.

Especially important will be to build into this new concept of multiple-purpose management ample provision for the variety of urban-based uses, including raw materials that go into industrial and consumer goods, outdoor recreation in its numerous forms, and just the sheer notion of preserving some wilderness areas relatively untouched. It isn't that many urban people will want to go into the wilderness, but most of them, I am convinced, value the idea that there is wilderness somewhere that somebody can visit occasionally. But, let it be noted, even the wildest of wilderness areas in the future will have to be protected and managed for that purpose.

Third, I come to the waste disposal problem. This is primarily an urban problem, although rural people are pretty good at messing up the landscape and the water courses; it's just that there aren't so many rural people and they are more spread out. The main thing here is to make the waste disposal part of the total concept of the process of production and use of resources and the environment, and not something extraneous and even irrelevant to these processes. If business firms or, for that matter, individual citizens look upon their activities which involve the natural environment as extending only to the point of production or consumption and not beyond into the phases of coping with the wastes and messes that may result, then something is basically wrong. If cleaning up the remains could become part of our habits and normal patterns of thinking, we should be much better off indeed. But unfortunately this is not so; we have inherited quite different ways of looking at the waste phenomenon.

Now we are faced with the very difficult task of changing our attitudes toward waste and our usual forms of behavior so as to enlarge the scope of responsibility of those who use the natural environment. Too long have we separated the producers and users and dumpers, as Stewart Udall calls them, from the job of tidying the place up. It is another of those bedeviling dualisms that run through American thought and action.

I can speak feelingly here from my own professional field of economics. The concept of gross national product has become one of the economist's most useful instruments of measurement. In another two years our GNP will break through the one trillion dollar ceiling. Unfortunately too much of our gross national product is really gross. It includes the value of all kinds of goods and services, some of which are shoddy if not downright harmful. It also includes the cost of such cleaning up of the mess as we begrudgingly do. The conservationist's national product, I suppose, would be the conventional gross national product minus the total national effort that would be necessary to restore the environment to a satisfactory condition and maintain it in that state.

Among economists conservation is usually regarded as a set of activities that aims to shift resource uses from the present to the future, and that would be reflected in a lower rate of discount of future net benefits. The modern economist might now go on to say that conservation also is a set of activities that aims to transfer labor and economic effort to the cleaning up or prevention of deterioration in environmental quality. Americans will become more truly affluent in proportion to their success in diminishing effluents. Increasingly we must design our laws and enforcement procedures, our systems of taxes and incentives, and our whole educational apparatus to bring waste disposal activities within the ambit of ordinary production and consumption processes. We are not done with the process when we produce the automobile or ride in it; we are truly done with it only when we have recycled the wrecked and abandoned jalopies back into the production-consumption system or have disposed of them in such a way that they no longer detract from the scenery. Americans, it is said, worship automobiles; if this is true we ought to reincarnate the dead ones into new cars or other useful products, or at least give them a decent burial.

Fourth, we don't know nearly as much as we should about why people do what they do with resources and to the environment. It is easy for the "pros" in any field to misapprehend what the people really want, to become out of touch with the way things really are. I think conservationists are right in their conviction that people want clean air and water, an unlittered landscape, and an end of billboards; but I'm a conservationist myself and may not see these things straight. There is the existential situation: lots of people do throw beer cans out of their car windows, and even more people pass by without picking them up. Maybe the beer cans are not quite so offensive as I think they are. Or, I become disturbed when more than a few hunters, fishermen, or picnickers cluster in the same area; but I notice that this feeling frequently is not shared by the others who seem to enjoy lots of company in the great out-of-doors.

What is needed, of course, is a wider and deeper perception of how individuals, alone and in groups, regard the natural environment, what they want from it, and how much effort and money they are willing to devote to maintaining its quality. This kind of research falls to the psychologists and sociologists primarily, but also to the architects and planners. Understanding the visual perception of the city and the country, on the part of both city and country people, is basic to workable conservation programs. The time perception of the environment is equally important: why are some people able to look way ahead to the future environmental consequences of present actions, while others can't see beyond the day after tomorrow?

Our notions of crowdedness seem to me rather primitive; they take insufficient account of structural and management devices for overcoming it. I went camping in a state park not long ago. Everyone there complained of overcrowding in the park. What they really meant was that the single available campground was overcrowded. But with some good landscape planning and some funds for additional roads and facilities the park could easily have accommodated ten or a hundred times as many people with no sense of crowding. In that case the perception my fellow campers had of the park and the camping experience would have been altogether different. Recreation carrying capacity hinges largely on the quality of planning and amount of investment in development.

We are only beginning to disentangle the numerous subjective and objective elements that make up a pleasing environment; yet this is the necessary first step in planning better environments. This goes for the city environment, the suburban environment, the rural environment, the wilderness environment. To be successful, conservation, like other programs of action, must be based on knowledge and the research which builds knowledge.

Fifth, if conservation is to become more relevant to an urbanizing society, conservationists must contemplate more seriously the creation of some new institutions through which to do the job. To begin with, many more land and water areas will have to be acquired or otherwise dedicated to outdoor recreation and preservation of natural beauty. Inter-jurisdictional authorities, federal and state loan and grant programs, alliances between particular cities and particular rural counties, and large city-country regional arrangements are among the possibilities. The Land and Water Conservation Fund has given new momentum to the acquisition and development of new recreation areas. The Nature Conservancy is moving dynamically and flexibly to maneuver additional land from private hands to public or trust status.

For some time I have been advocating a Maine Coastal Park and Recreation System, under combined state, local, private, and perhaps federal auspices, which would ultimately be made up of hundreds of choice scenic and recreation areas scattered along the 3,500 miles of the Maine coastline. These areas would be acquired as individuals wanted to sell or grant preservation easements; no land would be condemned. All the areas would be developed and managed at high standards of attractiveness and service, and would be publicized as an inter-related system of coastal beaches, rocky promontories, wooded hills, nearby lakes, and off-shore islands. Privately held areas could also be included as long as they measured up to the standards. Some 35 million persons live within the Boston-Washington megalopolis, a day's drive away, or two at the most. Some half a billion Europeans and North Americans are within a day's jet flight. Special efforts should be made to attract urban visitors from both groups. But all of this—with appropriate variations this systems approach could be applied elsewhere—will require new institutions, new kinds of planning, finance, and management if the inherent possibilities are to be realized.

Each city or metropolitan area in the country ought to be thinking in terms of its own park and recreation system, which would include not only areas within its own boundaries but also more distant areas offering mountains, forests, shoreline, and other features not usually available within cities. Frequently urban jurisdictions can concert their efforts along these lines, as in the case of the nearby Northern Virginia Regional Park Authority. In developing these systems people more than nature should be at the center of concern, and the new institutions should reflect this orientation.

Finally, I want to say a few words about the need to re-examine for an urbanizing America the whole structure of concepts, attitudes, instrumentalities, and programs which go under the heading of conservation. The conservation movement grew up out of a concern for forests, fish and wildlife, river development, wilderness, and soils. Conservationists tended to worry mainly about preserving enough of these things and were oriented to the natural sciences and engineering works. More recently, especially right after the second World War, the press of a rapidly growing population on the resource base became the central issue. More recently still, as it became apparent that new technology, substitutes, and economic advance generally could probably cope with tendencies toward increasing scarcity (at least in North America) for the next few decades, concern shifted to the quality of the natural environment rather than the sheer quantity of raw materials. Urban and industrial growth seem rather suddenly to have carried us into a danger zone in which environmental degradation and waste disposal problems threaten to engulf us. New technology adds problems faster than means for handling them can be readied—the SST with its sonic boom; conventional electric plants with their thermal pollution; nuclear power plants and problems of handling radioactive wastes; even the non-returnable, non-destructible bottle with its plastic permanence on the landscape. With all this has come also the clamor of millions of people for a cleaner, healthier, more attractive environment. The Virginia Legislature meeting now to revise the state constitution, is debating a new article guaranteeing the right to a clean and pleasant environment; a proposal to amend the federal constitution in the same way is also under consideration.

The rethinking and restructuring of conservation that I am calling for will have the following characteristics, among others:

—It will be based on people, their habits, desires, and modes of behavior, as much as on natural areas, wildlife, soil, and water. It will make full use of the insights of the behavioral and social sciences as well as the natural sciences.

—It will take full account of the overwhelmingly urban and urbanizing aspect of our society; that is to say, conservationists will aim to contribute to the solution of the great urban problems of crime, delinquency, lack of open space and fresh air, poverty, transportation, education, racial tension, riots, and need for outdoor recreation.

—It will conceive of new institutions and programs, whole new concepts of resource and environmental management and use, which will incorporate urban and rural resources, urban and rural governments, urban and rural people. And it will extend to all the countries and peoples of the world.

—It will foster new educational approaches at all levels and in all subject matter fields and disciplines so that the coming generations, nearly all of whom will live mainly in cities and suburbs, will understand better what will be required of them if the good earth spoken of so eloquently by the astronaut last Christmas Eve is to remain good.

—It will, in short, fashion a human ethic to go with Aldo Leopold's land ethic in which the quality of the natural environment and a sufficiency of resource materials and services will be placed in the perspective of the rising quality of life itself on this planet toward which all persons at their best will strive.

CLOSING REMARKS

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

Thank you very much, Dr. Fisher. That was a splendid summary. Joe, we are most appreciative of your efforts in preparing an outstanding resumé.

I am delighted to see this large crowd still here at the closing hours of this Conference. We have come to the end of another very successful North American Wildlife and Natural Resources Conference.

In closing, I want to pay our sincere respects to Dr. Walter O. Hanson of the Forest Service, who represented The Wildlife Society this year. He was of tremendous help.

You know, it is always a big job to put this Conference on. We will be starting again in a few weeks with plans for next year and will launch right into work on the next Conference. Walt did an outstanding job this year. We are most appreciative of the help and cooperation we have gotten from him and from his predecessors of former years.

We are also grateful to the working press. The coverage has been good. I have not had a chance to see a newspaper recently, but have recently heard reports that they have done a good job.

I know that Dan Poole has worked hard, not only in helping to formulate the program, but in preparing the papers that have been made available in the press room.

We want to thank the Washington Convention and Visitors Bureau for its assistance in helping with the registration and other details of this meeting in Washington.

I believe that all of you will agree that the Washington Hilton has done a good job. The food has been good, the service has been excellent, the meeting rooms have been adequate, and we are most appreciative.

With regard to the registered attendance, if we were interested in the numbers game and had I realized before they closed the registration that we were within one person of the all-time record registered attendance, I would have gone out and pulled someone off the street.

At any rate, in 1935, at the first North American Wildlife Conference, we had a registered attendance of 1372 people. In 1953, here in Washington, the next closest figure showed a drop to 1356. In 1957 it went back up to 1372; and here we are today wit ha registration of 1371, which is within one person of the top figure![1]

Of course, this doesn't mean anything because, as you know, we do not make a charge or give any incentive for registering. I know that there were many people present who did not register. Even at best, we never get over about 80 percent registration.

Incidentally, from talking with people at the reception last night, I found we had about a fourth of the United States Senate here last night. We also had a goodly number of members of the House of Representatives.

We are now at the close of our meeting and, as I always do, I want to pay my respects to the Institute staff and to our field men all of whom are of tremendous help in putting on this Conference. I am not sure that he average person who comes to these meetings year after year fully comprehends the fact that the Wildlife Management Institute staff works the year around on this Intenational meeting.

Rose Deiter, my secretary, hasn't been doing a thing for weeks except work on this Conference, trying to take care of the listings and bookings of the members of Congress and everybody else that we had at the banquet. Therefore, I want to thank not only Rose, but the members of the field staff who have been in charge of the meetings and looked after all the details. I want to thank Jim Trefethen also.

In closing, I wish to have those patient ladies who put up with our conference work year in and year out stand up—Mrs. Gabrielson and my wife, Bess, who, as of our anniversary last night, has put up with me for 47 years. Therefore, I would like to have both Clara and Bess stand.

The same expression of appreciation goes to Dorothy Poole.

We are going to Chicago next year. The Thirty-Fifth North American Wildlife and Natural Resources Conference will be held at the Palmer House from March 22 through 25. The National Wildlife Federation will meet immediately ahead at one of the other hotels in Chicago.

With that, I hope I will see many of you at the other conservation meetings throughout the year. Joe Fisher, thanks again for the magnificent job you have done. This meeting is now adjourned.

[1]Late registration brought the total to 1379.

REGISTERED ATTENDANCE

ALABAMA

W. L. Holland, Jr., Charles D. Kelley, Claude D. Kelley, Raymond D. Moody, Dan W. Speake.

ALASKA

Ed Bellringer, Mr. & Mrs. A. W. Boddy, Frederick C. Dean, Sue Dean, Jack C. Didrickson, Lee Glenn, Joe C. Greenley, David R. Klein, Robert E. LeResche, Alex H. McRea, Sig Olson, W. L. Pengelly, Robert A. Rausch, George F. Roskie, Ronald J. Somerville, Senator Theodore F. Stevens, Robert B. Weeden.

ARIZONA

David E. Brown, Glen D. Daly, R. A. Jantzen, Ross Manes, Lyle K. Sowls, Cong. Morris K. Udall, Fred V. Weiler.

ARKANSAS

William J. Allen, D. Leroy Grau, Robert M. Jenkins, James E. Miller, Robert A. Pierce, N. A. Winter, Jr.

CALIFORNIA

Harold H. Biswell, Maynard Cummings, William Dasmann, Curt Hammit, Gladwin Hill, Dick Hubbard, Cong. & Mrs. Harold Johnson, Howard R. Leach, A. Starker Leopold, Kenton C. Lint, Mrs. Kenton C. Lint, Wally Macgregor, Michael McCloskey, Ray J. Nesbit, Richard S. Peterson, Thomas W. Riley, A. Edwin Smith, Richard D. Teague, Julius Von Nostitz, Marshall White.

COLORADO

Senator Gordon Allott, L. Paul Applegate, Maurice D. Arnold, Alex Cringan, John W. DeGrazio, James H. Enderson, Robert L. Evans, Floyd L. Getz, D. L. Gilbert, Mr. & Mrs. A. F. C. Greene, Jack E. Gross, Roger P. Hanson, Peter Hansson, Mr. & Mrs. Ralph R. Hill, E. H. Hilliard, Jr., E. R. Kalmbach, Charles M. Loveless, Terry A. McGowan, Charles L. Mahoney, Julius G. Nagy, Wayne W. Sandfort, Ron J. Slonaker, Dwight R. Smith, Dr. & Mrs. Gustav Swanson, Florence Towsend, Joe Townsend, Charles Wallmo, Harry R. Woodward.

CONNECTICUT

John M. Anderson, Theodore B. Bampton, Philip Barske, Mr. & Mrs. S. H. Berwick, Mary Anne Berwick, John A. Bissonette, Douglas L. Brooks, Charles Dickey, Rudy Frank, Michael J. Gawel, Peter A. Jordan, E. S. McCawley, Jr., Robert D. McDowell, Stan Quickmire, Edward Ricciuti, Charles O. Williams.

DELAWARE

Lloyd Alexander, Frederick C. Bonner, William K. duPont, Anthony Higgins, Robert E. Jones, John T. Linehan, Betty J. Linehan, Robert Munro, Robert W. Patton, Mrs. John H. Prest, Wilbert Rawley, Mr. & Mrs. John W. Whitby, Norman Wilder, George R. Wright.

DISTRICT OF COLUMBIA

John H. Abrahams, Jr., Arthur C. Allen, Clark P. Baker, Richard C. Banks, T. S. Baskett, James E. Beach, J. P. Biniek, George F. Blackburn, John G. Blair, John Stuben Bord, MD, Walter S. Boardman, Harry K. Bourne, Stewart Brandborg, Charles T. Broyhill, Mrs. Marguerite Broyhill, Betty Brubaker, Maria Buchinger, Noble E. Buell, Gardiner Bump, Robert Cahn, Hon. J. Phil Campbell, John Carver, Warren L. Cheek, Ernst Christensen, Louis S. Clapper, Ed Cliff, Lawrence V. Compton, Harold J. Coolidge, George Crossette, H. E. Crowther, Frank Daniel, Stuart Davey, Raymond F. Dasmann, Maj. Gen. H. C. Davidson, Jeanne Davis, Robert L. DeLong, Robert T. Dennis, Thomas E. DeVaney, Philip A. Douglas, Philip A. DuMont, Allen J. Duvall, James T. Dwyer, W. W. Dykstra, Rev. Edward L. R. Elson, Fred Evenden, Fred S. Farr, F. H. Farrar, Jack Fauntleroy, Joseph L.

Fisher, F. Fraser Darling, John George, Chuck Giesey, Bill Gilmour, H. R. Glascock, Jr., Cass Gluszek, Mr. & Mrs. John S. Gottschalk, Kenneth E. Grant, William C. Grayson, Mr. & Mrs. C. R. Gutermuth, John L. Hall, Donald Hankla, Reynolds Harnsberger, John Harper, Mary Hazel Harris, Van T. Harris, Bill Hart, George W. Hartzog, Jr., Martha T. Henderson, Jack Hess, Willis L. Hobart, E. J. Hodges, Mrs. E. J. Hodges, Fred Hornaday, Sydney Howe, George Huber, Mr. & Mrs. Michael Huduba, Lynn H. Hutchins, Robert F. Hutton, Anthony Inglis, Raphael Jingu, Carl J. Johnson, John C. Jones, Mrs. Wilma A. Jones, Lt. James J. Jordon, Stuart Kaufman, Hubert Kelley, L. H. Kelso, Dick Kerr, Thomas L. Kimball, Willis King, Paul Knight, Mrs. Rosalie M. Koch, Capt. R. A. Kotrlaugn, Al Kubota, Emma Kuretich, Lee LaCombe, C. H. Lawrence, Mrs. Cazenove Lee, Mrs. Kenneth D. Lester, Miss Rae T. Lewis, Dr. & Mrs. Joseph Linduska, Mrs. Donald C. Lusen, James T. McBroom, Joseph M. McCabe, Keith R. McCarthy, J. C. McClellan, Mr. & Mrs. Donald A. McCormack, Mr. and Mrs. John C. McCormack, John R. McGuire, Ray McGuire, Bob Martin, Mr. & Mrs. John Mattoon, Howard A. Merrill, Edward J. Michelson, Herbert H. Mills, Gale Monson, Joe C. Moore, Cliff Morrow, Kerry A. Muller, Michael Nadel, Gerald M. Nugent, Rice Odell, E. A. Oren, Bernie W. Palas, Kenneth B. Pomeroy, Richard Pardo, Jerry Parker, Lloyd E. Partain, Milton A. Pearl, Ted S. Pettit, Daniel A. Poole, Sal J. Prezioso, Harry E. Radcliff, Boyd L. Rasmussen, William L. Reavley, Louis Reed, Neil J. Reid, Dwight F. Rettie, James A. Richardson, S. Dillon Ripley, George C. Ruhle, R. M. Rutherford, Theodore Ryder, Dan Saults, John F. Shanklin, Mrs. C. F. S. Sharpe, Martha Sherman, Willistow Shor, Walter B. Smalley, Anthony Wayne Smith, Morton M. Smith, R. J. Smith, Spencer H. Smith, Spencer M. Smith, Jr., George Soto, Adolph Stebler, Philip J. Stone, Charles D. Stores, Dick Stroud, Maurice Sullivan, Dottie Taylor, William R. Taylor, Barry Tindall, Dick Titus, Trude Toncray, William Towell, Barbara Tufty, Abe Tunison, Lloyd Tupling, Louis R. Van De Velde, Richard W. Wagenen, Maj. R. H. Wagner, Bob Waldrop, Elizabeth S. Wallace, O. L. Wallis, Stanley Weintraub, Josh Whetzel, William A. White, Judith A. Wiebe, Adele N. Wilson, Chester E. Wright, Marvin Zeldin, Gordon K. Zimmerman, Clem Zinger.

FLORIDA

Herb Alley, George W. Cornwell, E. Dale Crider, O. Earle Frye, Joe R. Knowles, E. V. Komarek, Ney C. Landrum, Jim Powell, Mr. & Mrs. Don Southwell, Cong. Robert L. F. Sykes, Alexander Sprunt IV, H. E. Wallace.

GEORGIA

J. David Almand, Frank Bowers, Mr. & Mrs. E. E. Carlson, E. L. Cheatum, Jack Crockford, Leslie B. Davenport Jr., Sharon Davis, Leonard E. Foote, George A. Gehrleen, W. C. Greenway, Joseph A. Harris, Duff Holbrook, James H. Jenkins, A. Syney Johnson, Robert G. McLean, R. Larry Marchinton, Elizabeth Mason, C. Aubrey Nelson, Don Nichols, C. J. Perkins, Paul D. Schumacher, F. J. Silva, J. D. Strange, James M. Sweeney, John R. Sweeney.

IDAHO

Ernest E. Day, Dr. William B. Durbon, Hugh Harper, R. J. Holmes, Maurice Hornocker, F. Jones, Sen. Len Jordan, Richard Knight, Thomas A. Leege, Sen. Frank E. Moss, David Neider, Ray Sims, Glenn Stanger, Ernest Wohletz, J. R. Woodworth.

ILLINOIS

Ray Banys, Mrs. Edgar Bellrose, Mr. & Mrs. Frank Bellrose, A. J. Boehm, Dr. & Mrs. George V. Burger, Thomas R Evans, N. W. Hosley, Robert L. Jarvis, W. D. Klimstra, Edward Kozicky, Ronald F. Labinsky, Clifford G. McIntire, John Madson, F. C. Pullman, Mr. & Mrs. William Rutherford, Glen C. Sanderson, J. Henry Sather, Dale E. Whitesell.

INDIANA

Dr. & Mrs. Durward L. Allen, Thomas W. Hoekstra, Donald E. Patrick, Seral I. Warren.

IOWA

Robert Barratt, Floyd A. Bishop, Bill Poswell, William C. Brabham, James L. Clark, Arnold O. Haugen, Cong. John Kyl, Fred A. Proewert, Earl T. Rose, R. C. Russell, Dr. & Mrs. Milton W. Weller, Mike F. Zaik.

KANSAS

Harold L. Gladfelter, George C. Halazon, F. Robert Henderson, R. J. Robel.

KENTUCKY

Bernie Carter, William H. Casey, Minor Clark, Jim Durell, Louis A. Krumholz, Arnold L. Mitchell, J. C. Salato, Burnis Skipworth.

LOUISIANA

Charley Bosch, Hurley Campbell, Arthur L. Darnsteadt, J. W. Fruchtnicht, Leslie L. Glasgow, Gerald E. Gunning, Clark Hoffpauer, Fant Martin, Richard K. Yancey.

MAINE

Donald K. Christie, Malcom W. Coulter, Frederick F. Gilbert, Ada Graham, Frank Graham, Dr. & Mrs. Howard Mendall, Mr. & Mrs. A. D. Nutting, Ray B. Owen, Jr., S. D. Schmnitz, Ronald T. Speers, Mr. & Mrs. Howard E. Spencer, Jr.

MARYLAND

C. E. Addy, Jim Applegate, Mrs. Albert S. Aiken, Charles B. Allen, Dr. J. Francis Allen, David R. Anderson, Ralph Andrews, John B. Baker, Donald M. Bandel, Mrs. June A. Barkley, Edwin M. Barry, Earl Baysinger, Harold Berkson, Lawrence Blus, Mrs. Eugene J. Brady, Shirley A. Briggs, Laverne Brugger, John L. Buckley, Mr. & Mrs. Noble Buell, Bill Burton, Bonnie Lee Byrne, Harold C. Caldbaugh, Samuel M. Carney, Roy Castle, Dwight R. Chamberlain, Ken Chiavetta, Jerry S. Choate, Nancy C. Coon, Eugene Cowan, Dr. & Mrs. Walter F. Crissey, Robert L. Croft, Fred H. Dale, Clint Davis, Alfred Drew, E. H. Dustman, Jean W. Dustman, Howard Erickson, Ray Erickson, Robert A. Evans, Dr. & Mrs. Fred Evenden, Lester F. Fader, Benjamin M. Florence, Vagn Flyger, Edith Fredine, Gordon Fredine, Mrs. Judson C. French, Mr. & Mrs. Hugh Galbreath, William C. Gassaway, G. F. Gee, Dr. & Mrs. Aelred D. Geis, Charles D. Gish, Luther C. Goldman, James R. Goldsberry, Mrs. Leta R. Goudy, R. Doyle Grabarck, Arthur W. Greeley, Mrs. Linda C. Hall, Nancy Hardgrove, Ronald Hartman, Joyce S. Hayward, Robert G. Heath, Clare W. Hendee, Carlton M. Herman, Earl H. Hodil, William B. Holton, Larry L. Hood, Forden M. Hughes Patricia L. Hughes, Stanley M. Jepsen, Charles Kaczynski, James A. Kerwin, Ed Ketchen, Malcolm E. King Jerome N. Kline, C. Eugene Knoder, William C. Krantz, Philip C. Kreitner, C. E. Lane Jr., Mrs. Francis C. Lang, William B. Laslo, James A. Lee, Daniel L. Leedy, Robert R. Leyshon, Chuck Lobdell, Jerry Longcore, Elroy R. Lumb, Duncan MacDonald, Frank McGilvrey, John Maestrelli, Merle H. Markley, Elwood R. Martin, Kahler Martinson, Brooke Meanley, Roy G. Metzgar, James C. Miller, Charles R. Newby, Thomas G. Newman, Henry F. Nichol, David J. O'Neil, Ken W. Parker, Larry Pease, T. B. Plair, Charles B. Pletcher, Richard D. Porter, Mrs. Lois Pottorff, Robert Preston, Henry M. Reeves, Chandler S. Robbins, Eleanor C. Robbins, Carroll T. Ridgely, John P. Rogers, James L. Ruos, Mary Ruos, Albert E. Sanderson, Jr., Keith N. Schreiner, Robert F. Scott, John Serafin, John L. Seubert, George B. Shields, William Sladen, Glen Smart, David J. Smith, David L. Smith, Donald A. Spencer, James D. Stephenson, James O. Stevenson, William H. Stickel, Lucille F. Stickel, Jeff Swinebroad, Clinton D. Trefethen, Mr. & Mrs. James B. Trefethen, Ernest A. Vaughn, Constance M. Vitori, John Warren, Mr. & Mrs. Clark G. Webster, Edwin F. Weseley, Jr., David A. Wharton, Thomas W. Whittendale, Jr., Stanley N. Wiemeyer, William C. Wilson, Robert Wolf, Sandra Wood.

MASSACHUSETTS

Milton R. Anderson, W. R. Beckmann, Kenneth L. Bergstrom, Warren W. Blandin, Mr. & Mrs. Richard Borden. Robert B. Brander, Nelson Bryant, Carl Carlozzi, Russell A. Cookingham, Raymond K. Entong, Marie R. Gleason. Dorothy C. Gleeson, Fred Greeley, Frank Gregg. R. E. Griffith, Wayne Hanley. Charles Keene, Steven C. LaMarine, Allen H. Morgan, Paul R. Nickerson. Bill Pollack. Walter E. Rogers, Peggy Sheldon, Dr. & Mrs. William G. Sheldon, James M. Shepard, John Sinton, Les Smith, Jim Vilkitis.

MICHIGAN

David A. Arnold, Reeve M. Bailey, Charles Ted Black, Rainer H. Brooke, John Byerlich, Marvin Cooley, Archibal B. Cowan, Cong. & Mrs. John Dingell, Donald W. Douglass, Ben East, A. Gene Gazlay, H. W. Glassen, James L. Goudreau, Charles D. Harris, Maxine Herbert, Paul Herbert, George S. Hunt, Douglas Janousek, David H. Jenkins, Howard E. Johnson, Eugene Kenaga, John M. Kitchel. MD, Karl F. Lagler, Justin W. Leonard, Dale R. McCullough, Stanley A. Marcus, William W. Mautz, Edward J. Mikula, Herbert Miller, C. L. Movle, James L. Ourman, Jean Petoskey, John Petoskey, Merrill L. Petoskey, G. A. Petrides, William V. Reid. William L. Robinson, Elisabeth Shelton, Napier Shelton, Mr. & Mrs. Charles Shick. Eleanor H. Smith, Hanley K. Smith, Rollin D. Sparrow, Joseph Strait Jr., Howard A. Tanner, R. E. Trippensee, Jack VanCoevering, Mr. & Mrs. Paul H. Wendler, Larry Whitney.

MINNESOTA

Joseph Artman. Cong. John A. Blatnik. R. W. Burwell. Charles T. Cushwa. Wallace C. Dayton. Robert E. Farmers. Arthur S. Hawkins. Thomas S. Helget, James Jack, Robert L. Jessen, Mr. & Mrs. S. E. Jorgensen. Verne E. Joslin. Mr. & Mrs. James Kimball, Richard J. Mackie, Martin Magnuson, William H. Marshall. Elaine Meslow. Murray Olyphant, Ron Schara. Robert W. Sharp. Ted Shields, Donald B. Siniff, Carl H. Stensland, Bill Stevens, John Tester, James Thompson, David B. Vesall.

MISSISSIPPI

Gordon Gunter.

MISSOURI

Mr. & Mrs. P. G. Barnickol, Mr. & Mrs. Vernon Bennett, Allen Brohn, Gus E. Budde, D. M. Christisen, Bill T. Crawford, William Edler, Judy Frederickson, Leigh H. Frederickson, Larry R. Gale, Edwin H. Glaser, Mr. & Mrs. U. Reid Goforth, Ray Heady, Bud Jackson, Sherman Kelly, Leroy J. Korschgen, Dean A. Murphy, Bernice Nagel, Werner O. Nagel, Carl R. Noren, Charles Purkett, Dick Rotsch, Ken Sadler, Mr. & Mrs. C. W. Schwartz, Herb Schwartz, Helen Shouse, Mr. & Mrs. P. L. Shouse, Jack A. Stanford, Mr. & Mrs. Ed Stegner, Harold V. Terrill, Dick Vaught, James R. Whitkey.

MONTANA

Don Aldrich, James A. Bailey, C. J. D. Brown, Roger Bumstead, Bob L. Burkholder, John Craighead, Leroy Ellig, Robert L. Eng, John T. Harris, Harold Knapp, Senator & Mrs. Lee Metcalf, Tom Mussehl, Philip L. Wright.

NEBRASKA

Phil Agee, Bill Bailey, Willard Barbee, Dale Bree, Bruce Cowgill, Gary Drown, Harold K. Edwards, Mr. & Mrs. Wade H. Hamor, Larry C. Holcomb, Ken Johnson, M. O. Steen, Mr. & Mrs. Floyd C. Stone, Lee Wells, Larry A. Witt, Carl W. Wolfe, Robert Wood, Brandt J. Zimmerman.

NEVADA

Senator and Mrs. Alan Bible, Frank W. Groves, Mrs. Velma B. Johnston, John H. Meier, Michael J. Pontrelli, George Knox Roth, Paul T. Tueller.

NEW HAMPSHIRE

Maurice E. Bilodeau, Paul Bofinger, Lt. Col. G. Kreamer, David Olson, Hilbert R. Siegler.

NEW JERSEY

Mrs. Arthur Fenske, Robert C. Fringer, Dr. & Mrs. Fred H. Glenny, Philip Granett, Elmer B. Greet Jr., Robert H. Horwich, Francis L. Jones, John Lehman, Mr. & Mrs. E. Budd Marter, Alan Miller, Jerry A. Moore, Ted S. Pettit, Len Spiegel, George P. Spinner, Walter J. Wenzel, James R. Westman.

NEW MEXICO

Senator and Mrs. Clinton A. Anderson, Raymond J. Buller, John Crawford, Ladd S. Gordon, William J. Huey, Dale A. Jones, William T. Krummes, Mr. & Mrs. D. O. Rettinger.

NEW YORK

Maurice M. Alexander, John Bain, J. W. Beckman, Donald F. Behrend, Anne LaBastille Bowes, Lawrence P. Brown, Robert L. Brown. Dr. & Mrs. Harlan B. Brumsted, Carl W. Buchheister, R. D. Burroughs, Tom J. Cade, Victor H. Cahalane, Mr. & Mrs. Charles H. Callison, Robert Cherdack, Roland C. Clent, Ralph B. Colson, Clare Conley, George D. Davis, Daniel L. Dindal. Kenneth N. Dunbar. Larry Durkin, Robert M. Ferguson, Mr. & Mrs. Lyle A. Findlay, Mr. & Mrs. Herman Forster, Earl J. Franze, Ira Glick, Robert F. Gotie, William F. Gusey, Mr. & Mrs. Albert Hall, Lawrence S. Hamilton, Harry Hampton, A. B. Hatch, Jean Hewitt, Oliver Hewitt. Mr. & Mrs. William Hilts, Capt. Amos L. Horst, William Hubertus, W. K. Jenkins, Mrs. Kendall Jenkins, Mr. & Mrs. Alan Jupin. Stewart Kilborne, Carl King, Ralph Kirshner, Gerald John Kowalski, Channing R. Kury, W. Mason Lawrence. William Leathersich, Mr. & Mrs. Stanley Logan, Rich Malecki, Guy E. Manley III, C. W. Mattison, F. H. V. Mecklenburg, Heinz Meng, Clement E. Merowit, Aaron J. Moen, Mr. & Mrs. Robert E. Meyers. Earl F. Patric, James M. Ramakka. Henry G. Rippe, Bernadette Rippe, David J. Roslien. Roy I. Satre, Peggy R. Sauer, Alan Simpson, Joseph J. Shomon, Elvis J. Stahr, Willard F. Stanley Dr. Margaret Stewart, Daniel Q. Thompson, Elizabeth Titus, Martin A. Turner, David H. Wallace, William H. Warrick, Dr. & Mrs. Bruce Wilkins, Mr. & Mrs. Ed Zern.

NORTH CAROLINA

Keith A. Argow, Frank B. Barick, F. S. Barkalow Jr., Senator Quentin Burdick, Hugh Fields, W. R. Nicholson, Clyde Patton, Eugene Schwall, Kenneth A. Wilson.

NORTH DAKOTA

Philip Aus, Meslow E. Charles, H. F. Duebbert, Mr. & Mrs. Keith W. Harmon, Jerald O. Jacobson, Robert L. Morgan, Senator Carl Mundy, Harvey K. Nelson, Gary L. Pearson, Glen Sherwood, Dr. & Mrs. Paul F. Springer, Russell W. Stuart.

OHIO

Walter G. Adams, William Anderson, Dan Armbruster, Jack Barclay, Theodore A. Bookhout, Cameron A. Gililland, E. E. Good, R. Gregory Hawk, Lou Klewer, John W. Koerner, George Laycock, Robert Meeks, Lyle A. Nauman, Tony J. Peterle, Jim Robey, Charles Sauer, Thomas M. Stockdale, Stephen D. Warner, Donald W. Thompson.

OKLAHOMA

Bill Altman, Harold B. Cooksey, Farrell Copelin, Gene Dozier, John F. Hines, George L. Knapp, Fred P. Lewis, Stuart A. Marks, William Morgan, John A. Morrison, Charles M. Palmer, Paul Roeber, Buford Tatum, Glenn Titus, Mr. & Mrs. Elmer Vieth.

OREGON

Hugh C. Black, Robert L. Borovicka, John Chattin, Charles S. Collins, Mr. & Mrs. Verne E. Davison, George Eicher, John D. Findlay, Senator Mark Hatfield, George L. Hibbard, Howard F. Horton, Dayton O. Hyde, Fred V. Koehler, John McKean, L. Dean Marriage, William B. Morse, Leon Murphy, George Reed, P. W. Schneider, Thomas G. Scott, George A. Selbe, Hugh Smith, Mrs. M. T. Weatherford, Bill Wick, Howard Wight.

PENNSYLVANIA

Stanley A. Belfore, Eleanor H. Bennett, Robert J. Birlo, Betty L. Bowers, Glenn L. Bowers, Matt Brennan, Fred J. Brenner, Edwin Cooper, Mr. & Mrs. L. H. Cramer, Malcolm Crooks, Robert L. Cowan, Dottie Curtis, Albert M. Day, Thomas Dolan, J. Kenneth Doutt, Dr. Margaret T. Doutt, Robert E. Masnacht, Miss Beulah Fay, John L. George, Jon Ghiselin,, Fred Hartman, Willard T. Johns, Samuel J. Kern, Jack M. Kiracofe, Viola R. Kiracofe, Mr. & Mrs. Ed Kuni, Roger M. Latham, R. S. Lichenberger, James S. Lindzey, Steve Liscinsky, Russell M. Lucas, Ann W. Lucas, Lee M. Machemer, Don Marushak, Paul Mifelton, Seth L. Meyers, M. Graham Netting, J. Hugh Palmer, W. C. Richter, Harvey A. Roberts, Robert Sagar, Cong. & Mrs. John A. Saylor, Mrs. J. Lewis Scott, Sam Shaw, Dale E. Sheffer, Mr. & Mrs. Fred M. Simpson, R. Smith, Donald B. Snyder, James A. Thompson, Joe Vaughan, Alan Woolf.

RHODE ISLAND

Alfred L. Hawkes, Virgil J. Norton, Clarence M. Tarzwell, Donald J. Zinn.

SOUTH CAROLINA

James A. Cox, Roger Seamans, James W. Webb.

SOUTH DAKOTA

Daniel Call, Thomas C. Dunstan, Lee Eberly, Byron E. Harwell, Raymond J. Linder, John Popowski, Dir Progulske.

TENNESSEE

Roy H. Anderson, C. J. Barstow, Jim Burbank, Jack Chance, Ralph W. Dimmick, T. R. Dunguen, Evan Means, Virginia Means, V. K. Seigworth, Harold E. Warvel.

TEXAS

Ernest D. Ables, Earl L. Benkam, David Blankinship, Eric Bolen, Lorraine G. Bonney, Orrin H. Bonney, Gene Brown, Richard L. Bury, Clarence Cottam, Mr. & Mrs. Olan W. Dillon, Edward C. Fritz, W. C. Glazener, W. H. Kiel Jr., Wallace Klussmann, Charles Land, V. Lehmann, Leroy D. Limpus, Keith Ozmore, Charles W. Ramsey, Joe D. Rollo, Henry L. Short, J. R. Singleton, E. A. Walker, Senator Ralph Yarborough.

UTAH

Wayne H. Bohl, Mayo W. Call, J. Whitney Floyd, D. M. Gaufin, Norman V. Hancock, Ruth Helm, William T. Helm, S. M. Hirst, Philip N. Lehner, Jessop B. Low, A. R.

McConkie, Beatrice McConkie, Donald E. McKnight, Joseph F. Pechanec, Bud Phelps, Dr. & Mrs. D. I. Rasmussen, Frederic H. Wagner, Marylin Wagner, Gar W. Workman.

VERMONT

Senator & Mrs. George Aiken, Robert Fuller, Egbert C. Hadley, L. Dennis Paquette, Edward Soutiere, Shirley J. Strong.

VIRGINIA

William E. Ackernecht, David A. Adams, John W. Aldrich, Michael Arny, Samuel A. Arny, Robert M. Ballou, Gerald C. Baumer, H. F. Bauserman Jr., Ruth Bauserman, Jack H. Berryman, Harold L. Blakey, Louis A. Boll, Thomas J. Bond, Jim Bowyer, William C. Bullard, Gaylord I. Burke, Robert W. Campbell, Raymond G. Cason, William S. Clark, Henry Clepper, Mr. & Mrs. Lawrence V. Compton, H. S. Crawford, Dick Cross, Millard C. Davis, E. P. Lee Denson, Art Dickson, Mrs. Rose W. Dieter, Bruce Dowling, Glenn R. Dudderar, R. Franklin Dugan, G. B. Farrar, Arlen D. Feldman, Russell Fielding, Mrs. Theodora C. Foster, Dr. & Mrs. Ira N. Gabrielson, Edward Gangstad, Mrs. A. W. Gates, Mr. & Mrs. Robert H. Giles Jr., Mr. & Mrs. Virgil Gilman, Robert E. Gordan, Mrs. Edward Graham, James C. Gritman, Richard W. Gross, Mrs. Sara Halliburton, Henry A. Hansen, Helen L. Hanson, W. D. Hanson, Jim Harlan, Richard F. Harlow, Frank Harmon, Keith Hay, Lt. & Mrs. Phelps Hobart, Robert G. Hooper, John F. Hosner, Paul Howard, John D. Hunter, Walter E. Jenske, Hugh A. Johnson, Mr. & Mrs. R. E. Johnson, Fred L. Jones, David O. Karraker, W. H. Kennedy, Roy L. Kirkpatrick, Tom Kurz, Bob Latimore, Helen M. Lawson, Roxie C. Laynourne, Roy H. Ledford, Ross Leonard, Maurice H. Lundy, Mr. & Mrs. James McBroom, Robert B. McCartney, Mrs. Audrey McFadyen, Burd S. McGinnes, Mrs. Cathlyn S. McInteer, James F. McInteer Jr., Juanita Mahaffet, Richard H. Manville, Charles J. Marlen, M. A. Marston, William E. Martin, Bill Massmann, John E. Meyering, Robert C. Milne, Henry S. Mosby, Ben Osborn, Alex T. Outlaw, Fred M. Packard, Jean Packard, Mr. & Mrs. J. W. Penfold, Barry L. Peterson, Chester Phelps, Mrs. Robert Pitner, Nell T. Prior, Joseph F. Poncochar, Charles E. Randall, Richard A. Rasp, David F. Reynolds, John E. Rhea, Thomas W. Richards, Colin Ritter, Bob A. Robinson, Mr. & Mrs. Theodore Rogowski, James S. Rouse, James C. Salinas, James W. Salyer, Maj. F. N. Saterlee, B. J. Schaefer, E. A. Seaman, G. L. Smith, William Shepherd Smith, Jr., F. G. Spoden Jr., V. Daniel Stiles, Marshall L. Stinnett, Bruce Stollberg, Neil J. Stout, Don Strode, Allan Studholme, Albert H. Swartz, Lloyd W. Swift, Dr. & Mrs. Lee M. Talbot, Glenn F. Tiedt, A. H. Underhill, James F. Voelzer, Earl T. Walker, Vern Walker, Byron B. Wates, Robert T. Webb, Roy C. White, David L. Wickens, Bruce Wiersma, Robert D. Wildman, Harvey Willoughby, Cynthia E. Wilson, Jack B. Woody, A. T. Wright, Marvin L. Yates, Gregory Zafros.

WASHINGTON

Prentice Bloedel, John Biggs, Carl N. Crouse, Lee Eberhardt, Clifford H. Fiscus, John C. Hendee, George W. Hess, Lew Holcomb, Senator Henry M. Jackson, Charlotte Lauckhart, J. Burton Lauckhart, William H. Lawrence, Howard E. Nelson, Agnes Pettie, Robert G. Pettie, Clem S. Stearns, R. D. Taber, James P. Wheeler.

WEST VIRGINIA

Theodore C. Fearnow, William H. Goudy, Paul L. Haggard, David E. Samuel, Arnold F. Schulz, Robert Leo Smith, Mr. & Mrs. Jack Ward Thomas, Mr. & Mrs. David E. White.

WISCONSIN

F. M. Baumgartner, C. D. Besadny, Robert S. Ellarson, Jim Gootemaat, Martin Hanson, J. J. Hickey, Richard Jahn, Dr. & Mrs. Laurence R. Jahn, Robert A. McCabe, Mrs. G. L. McCormick, B. C. Prentice, MD, John Prentice, Robert E. Radke, Orrin J. Rongstad, Mr. & Mrs. William Ruth, Charles L. Stoddard, Daniel Trainer, Roy G. Tulane.

WYOMING

Kenneth L. Diem, Fred Eiserman, George Gruell, Mr. & Mrs. Carroll R. Noble, Earl M. Thomas.

GUAM

Gerald S. A. Perez.

CANADA

Alberta: Dr. & Mrs. John P. Kelsall, Andrew Radvanyi. *British Columbia:* Ian McT. Cowan, Peter H. Pearse, *Manitoba:* Eugene F. Bossenmaier, Dr. & Mrs. K. H. Doan, G. W.

Malaher. *NWT:* P. Kwaterowsky. *New Brunswick:* Bruce S. Wright. *Nova Scotia:* Donald G. Dodds, Pearl H. Dodds, Merrill Prime, Sylvia J. Prime, Dr. & Mrs. Harrison F. Lewis. *Ontario:* Keith Acheson, H. M. Babcock, J. Roger Bider, Hugh Boyd, Lawrence C. N. Burgess, Gilles Carpentier, C. H. D. Clarke, George A. Hamilton, Bruce C. Johnson, Hoyes Lloyd, Robert D. Lockwood, Bill Miller, Norman R. Oldfield, Joy Oldfield, Nolan G. Peret, Stuart S. Peters, Douglas H. Pimlott, Phil Rhynas, F. A. Walden, Mrs. W. Harold Watson, James Woodford. *Quebec:* William D. McLaren. *Saskatchewan:* Hugo S. Maeipaard.

MEXICO

Dr. & Mrs. Enrique Beltran.

PUERTO RICO

Frank H. Wadworth.

FOREIGN

Italy: Thane Riney. *New Zealand:* Kaj Westerskov. *Sweden:* Lennart Grenestedt, Dr. Lundholm. *U.S.S.R.:* Victor F. Lishcenko, V. Pryman. *Union of South Africa:* G. C. van Drimmelen. *United Kingdom:* David Nisan.

INDEX