TRANSACTIONS
of the
Forty-sixth North American Wildlife and Natural Resources Conference

Conference Theme:

Resource Management for the Eighties

March 21–25, 1981
The Shoreham Hotel
Washington, D.C.

Edited by
Kenneth Sabol

Published by the
Wildlife Management Institute
Washington, D.C.
1981

Acknowledgment

The editor thanks Mrs. Lyla Baumann for her assistance in reading proofs and preparing the manuscript for publication.

Additional copies may be procured from the
WILDLIFE MANAGEMENT INSTITUTE
709 Wire Building, 1000 Vermont Ave.
Washington, D.C. 20005

Transactions of the Forty-sixth
North American Wildlife and Natural Resources Conference
ISSN 0078-1355

Printed in
U.S.A.
by
Automated Graphics Systems, Inc.
White Plains, MD 20695

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Formal Opening

Daniel A. Poole
President
Wildlife Management Institute
Washington, D.C.

Good morning, ladies and gentlemen. Welcome to the 46th North American Wildlife and Natural Resources Conference.

As is characteristic of Washington any time there is both a new Administration and a new party in power, the city abounds with hopes and fears. The new army of occupation hopes that changes will match campaign rhetoric and the longer term residents fear that they may. A time-honored verse aptly describes such a setting of aspiration and apprehension:

"As I was going up the stair,
I met a man who wasn't there.
He wasn't there again today.
I wish, I wish, he'd stay away."

For the next few minutes, I want to climb the stair. To look at issues that may or may not be there.

The foremost issue of all is the President's budget revisions for the coming fiscal year. Funding drives the whole process of government. Substantial reductions are being sought, including in the natural resources area.

The present state of the economy is a critical national problem. A disordered economy can thwart all national goals and objectives, including those for natural resources. Our capability to accommodate needs, both as a society and as individuals, has been and is being seriously eroded. Few are blameless; not government, not business, not labor, and not all those whose appetite for self and peer benefit exceeds our economic system's capabilities to respond. Simply throwing money at problems is no solution, because government frequently spends inefficiently that which it receives from all of us. And it is human nature, also, to suggest that savings best can be achieved in sectors about which one cares or understands the least. We have reason for apprehension, because the need for regular and balanced investment in natural resource programs has not been accepted by any recent Administration.

One of President Reagan's economic circuit-riders observed recently that "Good budgeting is the uniform distribution of dissatisfaction." That may be satisfactory from an economist's standpoint. But it is in severe error from the standpoint of husbanding natural resources, the foundation of all wealth.

Senator James McClure, new chairman of the Senate Committee on Energy and Natural Resources, stated budgeting objectives better at a recent hearing. "Some of the required changes will be painful," he said, "and we must assure equity in the distribution of the consequences of necessary changes."

The Land and Water Conservation Fund has been a major source of land acquisition money for national parks, forests and wildlife refuges, and for state recreation purposes as well. Fund outlays would be reduced drastically under the President's plan, and an amendment would be sought to permit the Fund's use for national park maintenance. National parks also would receive more than $100 million of new money for facility rehabilitation this coming year. Use of Fund receipts for national forests and wildlife refuges would be curtailed severely, if not entirely.

So here we go again—about to embark on yet another crash program. And right on the heels of the dismal failure of the Bicentennial Land Heritage Program, launched with much fanfare in 1977. It fell far short of its promise for the national park and wildlife refuge systems.

Crash programs do not adequately serve our interest in parks, wildlife refuges, forests, range or other resource areas. Evenhanded and consistent investment is required. But well-reasoned and orderly efforts are not a capstone of the Federal Government. Witness the last Administration's refusal to face up to the needed investment levels identified under the Forest and Rangeland Renewable Resources Planning Act.

I hope that when the appropriations process is completed for the coming year that the Administration and Congress will have demonstrated understanding that important natural resource programs should proceed in a balanced manner. There are no sides to this issue. But, unfortunately, politicians have yet to accept the principle that maintenance of resource productivity and environmental quality requires regular and adequate investments.

Attention is being attracted by the Sagebrush Rebellion—its aims and its chances for success. Official Washington's latest line is that this effort to strip the United States of its lands can be defused if the Bureau of Land Management and the Forest Service become "good neighbors" to state and county governments, permittees, lessees and others. There is concern—and there should be—that being neighborly means that an agency will be expected to belly-up whenever a permittee, lessee or politician snaps his fingers.

Certainly, there is no objection to public land agencies being neighborly, providing that they can go about their work in a professional and nonpolitical manner. Even the agencies admit to changes that could ease the frictions and frustrations of doing business with government. But there should be no retreat from the stand of honoring all legal uses of public lands and improving their capability to yield services and resources without impairment of productivity. To do otherwise would be to administer the lands contrary to law and to ignore the reasons that such laws were enacted in the first place.

Washington's view of what can be done to defuse the Sagebrush Rebellion falls short of the expectations of the League to Advance States Equal Rights. This group, using the acronym LASER, is the spear carrier for restive western economic interests. Asked what lands it would strip from public ownership, a LASER official said all federal lands, except national parks, monuments and active military reservations. He said, too, that transfer of title to state governments was merely a ploy to reduce public outcry and that the lands should pass from state to private ownership promptly.

LASER no longer stands alone. It must share the stage with others. Slow to react because of their thought that the Sagebrush Rebellion would collapse of its far out demands, recreation, conservation, environmental and other groups, both West and East, are organizing to resist the divestiture effort as skillfully and forcefully as they know how. They also will be on the lookout for other things, such as modifying regulations, withholding appropriations, reducing personnel and administrative inaction, that would prevent improved management of these invaluable lands in the overall national interest.

Every time you hear the Sagebrusher's pitch for the return of public lands to the states, I call on you to respond, "Return, no way. The states never owned them in the first place."

Another suggestion coming from the new Administration is that there are enough national forests and wildlife refuges, and that national parks and monuments can be rounded out by exchange for federal holdings elsewhere. Even with its heavy tilt toward public land users and commercial interests, the old Public Land Law Review Commission was against that. Any attempt to use the lands of one agency to satisfy the goals of another will encounter substantial opposition.

Those who may think otherwise would be well advised to review the outcry some years ago when a trade of public lands in Oregon and Nevada was suggested for private holdings in the Pt. Reyes National Seashore. Dubbed the "Sweet Swap" after the name of the landowner, the proposal quickly ran aground. Despite occasional tiffs with their big neighbor, responsible local people are not about to sanction the passing of public lands into private hands to satisfy government's desires elsewhere.

There has been an outpouring of new national park authorizations in recent years. So many, in fact, that the National Park Service director has called for a halt. Some new areas are not of national park caliber. They are local or regional recreation projects that should be undertaken by other levels of government. Too often, unfortunately, responsibility for a park or recreation area is assigned on the basis of which level of government can be stuck with the bill. Uncle Sam loses that scam, time and time again.

One national park need clearly remains—a prairie national park in the great mid-continent grasslands. It likely cannot be acquired in the classical national park sense. But there are ample variations of less than outright control that could be used to assure that America will preserve, as a truly national scientific and cultural treasure, a remnant of the once seemingly endless ocean of native grasses.

Last year brought the enactment of the so-called Nongame Act, which offers some assurance that closer attention will be given to native animals not prized for food, fur or recreation. The Carter and Reagan budgets seek no funds to launch that modest effort. The Act also calls for a Fish and Wildlife Service study of alternative means of financing the program, such as by manufacturers' excise taxes on bird foods and related items. Wildlife's interest demands that this program be funded.

Attention this year is centering on the Council on Environmental Quality, its role and, indeed, its continued existence. In recent years, and particularly among the professional wildlife community, there has been increasing concern that the Council may be a good thing gone astray, that its position in the Office of the President has been abused. Properly directed and sensitively and sensibly used, the Council on Environmental Quality has great potential for focusing attention on and helping to resolve some of the truly major issues that are undercutting the quality of man's environment, here and abroad. Unfortunately, recent Presidents have used CEQ as a showpiece of personal interest in the environment rather than as an instrument to resolve the bitter head-butting environmental conflicts within government itself.

There are many other figures on the stair and only time will tell whether they are real or never were there in the first place. There is the utter necessity for renewing the Fur Seal Convention; enlarging the funding base for the Dingell-Johnson Federal Aid in Sport Fish Restoration Program; continuing the Cooperative Wildlife and Fishery Research Units; extending the Endangered Species and the Sikes Acts; enunciating a firm and fair policy regarding the fish and wildlife responsibilities of state and federal governments; curbing our national wanton waste of productive farmland; reducing soil erosion, that destroyer of an invaluable resource; terminating an antiquated law that diverts hundreds of millions of dollars of receipts from national forests and public lands to the purposes of the Reclamation Act, when those same lands consistently are denied sufficient funds to properly manage surface resources; and assuring that the 120-day job security countdown that ends in mid-May for the federal Senior Executive Service does not result in the appointment of purely political types to positions requiring professional resource training and experience. This is the first go-around for the Senior Executive Service, and the system is susceptible to abuse—unplanned or otherwise.

A final observation. I call your attention to a special film presentation in this room at 5:30 p.m. today. This will be the premier public showing of "America's Wetlands," a dramatic documentary produced for the U.S. Fish and Wildlife Service and the Environmental Protection Agency. You will find the details in the Conference program.

New Dimensions and Commitments for Federal Resource Programs

The Honorable James Watt
Secretary of the Interior
Washington, D.C.

Thank you for providing this excellent forum for my first speaking engagement as Secretary of the Interior. I am happy for the opportunity to address this gathering of North America's leading conservationists and authorities on fish and wildlife. Two months ago today I was confirmed by the Senate and sworn in at the White House. Since that time I have been immersed in the intricacies of reshaping the Department and enmeshed in discussions with congressional committees. During these two months I have made some major changes in the policies of the Department.

These actions have caused tremors in some segments of the conservation community. But let there be no mistaken views, this Administration will be in the mainstream of the conservation-environmental movement of America. Our management will be made up of real professionals.

The top two officials in the fish and wildlife areas of the Reagan Administration will be professional wildlife managers with experience as the chief executive officers of State fish and wildlife programs. In addition, we of the Reagan Administration have a proven and highly respected professional to head the National Park Service.

Today I want to share with you some of my views on conservation. I want to give you some of the reasoning for the actions which I have taken and will be taking.

There are four solid cornerstones in this Administration's conservation policy:

1. America must have a sound economy if it is to be a good steward of its fish and wildlife, its parks, and all of its natural resources.
2. America must have orderly development of its vast energy resources to avert a crisis development which could be catastrophic to the environment.
3. America's resources were put here for the enjoyment and use of people, now and in the future, and should not be denied to the people by elitist groups.
4. America has the expertise to manage and use resources wisely, and much of that expertise is in State Government and in the private sector.

All the actions which President Reagan or I have taken which impact upon conservation grow out of these principles.

This Administration *is* conservative. Conservatives *believe* in conservation—it's basic to our philosophy. We all want our children and grandchildren—all who come after us—to have the opportunity to experience nature—to exult in the beauty of this country. We will use the resources of the earth, but we will do so with the knowledge that mankind has been sustained by this earth for thousands of years and will be dependent upon it for generations to come.

When I became Secretary of the Interior I took an oath to uphold the law of the Nation which calls for the preservation of some lands and the development of other lands. This means finding a balance between competing uses. It also means finding that balance between how much we can use today without depriving future generations of Americans of the resources they too will need. This is what I swore to when I took the oath of office; this is what I believe in. This is what the President believes in.

Let's look at the four principles a little closer.

First, rebuilding the American economy as a prerequisite to continued strong conservation. In November the American people demonstrated that they agree our Nation is in grave economic peril. They gave an overwhelming mandate for an end to inflationary overspending and suffocating overregulation by the Federal Government. Those of us in the Reagan Administration are committed to fulfilling this mandate. I have responded by cutting more than one and one-quarter billion dollars from the Department's current budget and proposed budget for 1982. Some of these cuts are being accomplished through consolidation of redundant functions. In one instance we are shifting essential functions of the Heritage Conservation and Recreation Service to the National Park Service. In another, we propose replacing the Water Resources Council and Office of Water Research and Technology with a more efficient Office of Water Policy.

We are cutting out all State grants under the Land and Water Conservation Fund and limiting Federal acquisition expenditures to $45 million—and only for emergencies. We believe a good steward learns to take care of what he has before he takes on additional responsibilities. Where park expansion is critically needed, we will seek to work out exchanges of land with existing owners.

Throughout the Department there has been a severe belt tightening. We have looked at all programs; we have put many on the shelf. Some of these programs will come off the shelf in better economic times. We believe we have used wisdom in making these decisions. Congress has the final responsibility.

Moving on to the second cornerstone of conservation policy—the need for accelerated economic development on the public lands, especially for energy and strategic minerals. America is desperately in need of a national minerals policy which enables us to develop our own resources so that we will not be dependent upon imports from nations which could cut off supplies at any time or which could bankrupt us. Our national security and our economic well-being are both at stake because we have neglected the development of a meaningful minerals policy. This Administration will take action to safeguard the Nation.

I am making adjustments in policy to see that we have orderly exploration and development of needed energy and other mineral resources. We will do this in consultation with the States, with local governments, and with private landowners who would be impacted. And we will do it with full regard for the fish, wildlife and other natural values.

If orderly development of our energy resources with proper environmental safeguards is not allowed, economic, political, or social pressures could force the Federal Government to order a crash program under crisis conditions to develop the energy resources. If this were to occur, the destruction of our fragile ecological system could be experienced—particularly in my native West.

The third principle I listed at the outset is an orientation toward people. This Administration will be a good neighbor to the users of public lands and to the States. On all fronts we will be removing unneeded regulations and policies which have irritated people not only in the West but all over this country.

Our public lands, our forests, our parks, our refuges, our wilderness, our wild and scenic rivers—all should be managed in ways which directly or ultimately serve the needs of people. Our wildlife and fishery management programs, including our endangered species programs—these exist because it is in the interest of mankind to maintain a balanced and healthy natural world. Some areas must be set aside primarily for wildlife and fish. Other areas should be more intensively used. People make these decisions.

Look at our national park system. This was created so that people could forever share and enjoy the greatest natural treasures. It was not created to lock the treasures away from the people. In recent years the National Park Service has been pressured to grab for more and more lands. It has been pushed into recreation areas which might more properly be the domain of the cities, the counties or the States.

Our parks and facilities have been deteriorating. The public's access to the parks is being eroded. Our National Park Service has been fighting a valiant but losing battle. It's time to retarget our efforts and our money. It's time to round out the Federal estate. That's why I propose a halt to expansion of the park system.

That's why we need to look at what we have to make sure that it consists only of that which is truly unique and of national significance. We should not squander national tax dollars on non-national lands. That's why we are asking Congress to allocate $105 million from the Land and Water Conservation Fund for park maintenance and restoration. We want to see the truly national parks improved so that they can be used by the people. We do not believe that the parks nor any of our resources should be held for the exclusive enjoyment of the elite.

At the same time, we understand fully that there must be management which will assure that our use and enjoyment of parks, refuges, seashores and other areas does not in itself destroy them. We will not throw the gates open and say "Here they are, folks, help yourself." We will manage the lands.

This Administration has the confidence that our country has the expertise and the self-discipline to manage our resources properly. We believe that the key to conservation is management. Conservation is not the blind locking away of huge areas and their resources because of emotional appeals.

Man has altered nature. He must now provide a balance in the use of Nature's provisions. It is an awesome responsibility and one we cannot shirk. Wildlife and resources managers must be allowed to manage by the best scientific knowledge available and not be deterred from their task by emotionalism.

In this Administration we will be looking more and more to user groups to help pay the bill for this management. The Pittman-Robertson and the Dingell-Johnson programs have been great. Now there is some sentiment for expansion, and I applaud that possibility.

On the international front, we will be careful not to make agreements which are detrimental to State and Federal fish and wildlife programs.

In our conservation programs, we will be targeting our dollars to get the most management out of our investment. We're going to channel the available funds "to the ground"—the refuges, wildlife ranges, parks and public lands.

We are retargeting our effort in the Endangered Species Program so that we can try to help species recover rather than compiling endless lists of those which are endangered or threatened. The Endangered Species Program will be managed for scientific purposes, not for political or philosophical objectives.

These are some of the actions which we have taken in these past two months, and some of the thinking behind our actions.

My job is not an easy job, but it has its satisfactions. It is a pleasure to work with a President who understands natural resource issues. When I talk about BLM or the U.S. Fish and Wildlife Service or some other important resource managing agency, the President understands immediately. As Governor of our most populated State, with 50 percent of its land Federally owned, he learned about wildlife and about natural resources and he learned well. He is a man who has a great love for the outdoors, but who loves his country so much that he now finds himself able to enjoy the outdoors only on very limited occasions.

Let me close by reading a brief message from the President which pretty well summarizes and emphasizes what I have said:

> Our natural resources are a precious heritage which provide the basis for our national wealth and well-being. We have a sacred responsibility to manage them wisely.
>
> This 46th Annual North American Wildlife and Natural Resources Conference comes at a time when we are working to devise new approaches to achieving these vital conservation goals in the face of necessary fiscal self-discipline. Our country will be relying upon you and your colleagues to help us carry out the planned, orderly and scientific management of our wonderful wildlife resources as economically and as efficiently as possible.
>
> In your theme, "Resources Management for the Eighties," I perceive a dedication to a new beginning. May you have a most productive conference and every success in your conservation endeavors which lie ahead."

The Sagebrush Rebellion

Mike O'Callaghan
Executive Vice-President, Las Vegas Sun Newspaper,
Publisher of Henderson Home News and Boulder City News, and
Former Governor of Nevada (1971-1978)
Las Vegas, Nevada

A year ago an eastern journalist was in my office after spending several days examining what has become known as the "Sagebrush Rebellion." His eyes had been opened and he no longer viewed with amusement the intensity or design of the plan to take over federal land. He told me, "Just wait and see the reaction in Congress when people east of the Rockies understand what these rebels intend to accomplish." I just shrugged my shoulders and replied, "It won't be nearly as explosive as it will be when the western outdoors enthusiasts realize what is happening to them in their own backyard."

Today I am still waiting for the rock hounds, hikers, hunters, fishermen, photographers, campers, and just plain nature lovers to awaken to the goals of a few people exploiting western antagonism toward the Federal Government. Yes, and also antagonism developed toward the hand-holding relationship between some conservation groups and the Federal Government. A relationship that on many occasions dealt in a high-handed manner with western states and their residents. There is no doubt in the minds of fair people that enough instances of bullying have been recorded to bring about a response short of war only.

Let's take a look at the situation before I get into specifics.

If you draw a map on which the size of the states is an indication of population, instead of land area, everything west of the Mississippi River becomes quite small. Only California keeps some size. *Newsweek Magazine,* in conjunction with the presidential elections, depicted such a map last year. It showed the states in a size that was relative to voting strength in Congress. It was the land east of the Mississippi River that had size and lawmaking power. To give some indication of what this means, let us look at the two states in our nation which now have legalized casino gambling. One is Nevada, with 71 million acres (29 million ha) and a single vote in the House of Representatives. The other is New Jersey, with just five million acres (2 million ha), but 15 votes in the House. Nevada has the size, but New Jersey has the clout.

People east of the Mississippi River have fixed ideas of what the West is all about. Right or wrong, they maintain their own image of the land between old man river and that separate country called California. Most of them cannot comprehend the vastness of states like Nevada and Utah. Westerners do casually what Easterners do only after long planning. A western wife might suggest Thursday night that the family should go camping for the weekend. After work Friday, the family drives from, say, Salt Lake City over to Wendover. We treat a trip like that casually. There are no towns between the two sites.

In the East, the drive from Washington, D.C. to Philadelphia is the same distance. The driver passes through a dozen towns or cities. It is a trip made only on a special occasion.

On Thanksgiving Day weekend in 1970, a charter airplane bound from central

Nevada to California disappeared. You may remember the tragic story of the Gamblers' Special flight in which everyone died when the plane hit a mountain. The crash was in a remote area of the Sierras. It was August, nearly ten months later, when the wreckage was found. One Sunday afternoon in February, when the plane had been missing nearly three months, an editor in Illinois typed out a story request on his Associated Press wire. He asked, with no small measure of impatience, how an airplane could be missing for more than a few days. The question is typical of eastern understanding of the West. In Illinois, a plane crash would be in some farmer's field and would be found within minutes—hours at the most. That's not the case in the West.

We have prehistoric sites in Nevada that have been seen by perhaps a half dozen people in the past hundred years. There are remnants of wickiups abandoned by Indians at the end of the 1800s, and unvisited since. In the East, Indian rockshelters are difficult for archaeologists to study, because modern picnickers have used them for 200 years. In the West, the blackened rocks of a fire ring at such a site could have been left by Indians before Columbus landed.

The huge size of our land has kept it from being heavily populated, and has protected it from destructive visitors simply by its vastness. Wheel ruts remain impressed in the range from covered wagons which passed through over a century ago. Those wagons went on across the Sierras to California.

How can you explain that a horseback rider, given enough time and some route planning, can ride from Interstate 80 somewhere east of Wells, south to Moapa, cross country, without ever cutting a fence or passing through a gate. It is the same distance as going from New York to Pittsburgh, but you'd never be able to make that trip on horseback today.

When I was governor of Nevada it was not uncommon for my friends and relatives from the East to arrive in Las Vegas in the morning and call the capitol for a luncheon engagement. Following a short explanation that we were well over 400 miles apart, they would oftentimes settle for dining with me that evening.

Now let me give you an example of what helped make the so-called Sagebrush Rebellion acceptable to an uninformed public. The term "Sagebrush Rebellion" is the epitome of jingoism. It sounds western, horsy, outdoorsy and something any red-blooded, Levi-wearing westerner can identify with in good conscience. It is really the opposite of these things and, if successful, would in a matter of 20 years have westerners again singing, "Don't Fence Me In."

So why has it caught fire? Why are millions sitting by watching their western birthrights being threatened as a few politicians spend the taxpayers' money to take over the land now accessible to the general public? Don't the people understand what is happening to them or is it they just don't give a damn?

You might have a better understanding of the questions and the different answers you would receive from the citizens of Nevada if you lived in our State. Better yet, imagine that you and your family live in Beatty, Nevada. It is the hot summer of 1978 and you have been planning a weekend at the Ruby Marshes the first week of July. The Fourth of July falls on a Tuesday. By leaving home after work on Friday, you can arrive at the marshes high in the mountains about daybreak Saturday. You don't drive very fast when you are pulling your boat and have the car loaded with your most valuable possessions—a wife and four kids. It's 300 miles (483 km) but well worth the trip for a few days away from the heat. Next to

Lake Tahoe and Pyramid Lake, it is the largest body of cool water in the State of Nevada. It is a tiring but pleasant trip as you sing and eat away the long hours behind the wheel. You arrive as scheduled to find that a federal judge in Washington, D.C. issued an order keeping motor boats off the marsh. It seems impossible that a man about 3,000 miles (4,828 km) away, with the stroke of a pen, could spoil the plans for the weekend vacation of your family.

That's right. Federal Judge John H. Pratt, at the request of the Defenders of Wildlife, had signed an order ruining the holiday of hundreds of people and immediately took off on his own four day vacation and could not be reached.

Your holiday is ruined and when you hear several boaters are going to defy the court order, you give it strong consideration. But you don't put your boat in the water because it would be a bad example for your children. You grit your teeth and feel anger and frustration others have felt because of strange regulations and court orders coming from the banks of the Potomac River. Some day you'll have your chance to get even, but right now you might as well start that long hot trip home.

Here are some accounts from the Elko Daily Free Press, a daily evening newspaper, June 30, 1978 article:

> Power boats will not be allowed on the Ruby Lake National Refuge tomorrow because of an order issued in Washington, D.C. this afternoon.
>
> Larry Kline, manager of the refuge, called with the news this afternoon after being told of the order by his Washington office.
>
> Power boats were to have been allowed on a small area of the south sump of the refuge starting tomorrow, but a temporary restraining order sought by Defenders of Wildlife will prohibit their use, at least until July 10 when a hearing is scheduled on a permanent order.
>
> Defenders of Wildlife is seeking to stop the Department of Interior from allowing any power boats on the refuge, said Kline.
>
> The temporary order was signed by Judge John H. Pratt of the Washington, D.C. district court.

Nevadans still believe the last minute order by Judge Pratt was a conspiracy. 'hey only have to point to the large number of new wardens who appeared on the cene only hours after the court order was signed.

Further from the *Elko Daily Free Press* July 1, 1978 issue:

> Jack Hull, an Elko attorney and member of the local committee organized more than a year ago to resist more restrictive boating regulations at the Ruby Lake National Wildlife Refuge, today criticized yesterday's Washington, D.C. court order which prohibited all power boating at the refuge.
>
> Hull today issued this statement:
>
> "Recent actions and statements by Fish and Wildlife personnel and the timing of the suit indicate that this must be a collusive action by the U.S. Fish and Wildlife Service and the Defenders of Wildlife. It was totally irresponsible to let all these people travel for the Fourth of July weekend to use the marsh, and then to serve this order at the last minute.
>
> "It looks like it's time for the people of Nevada to demand the return of the Ruby Lake to the State of Nevada."

The same paper carried this story:

> Loreen Mariluch, a resident of Shantytown and proprietor with her husband of

> the Shantytown Grocery, reported about 9 a.m. that power boats were out on the Ruby Marshes today in defiance of a Washington, D.C. court order issued yesterday.
>
> Mrs. Mariluch said she estimates nearly 100 power boats had gone out on the marsh this morning, despite the presence of nine federal wardens dispatched to the marsh by the U.S. Fish and Wildlife Service.

Then the July 3, 1978 issue of the Elko paper read:

> State Senator Norman Glaser of Halleck and Nevada Fish and Game Commissioner Jack Taylor of Elko were among approximately 100 defiant boat operators who were "written up" on federal "Field Information Reports" during the weekend at the Ruby Marsh.
>
> Larry Kline, manager of the refuge and one of the federal enforcement agents at the marsh, said the report forms are to be forwarded to the U.S. Attorney for Nevada, who will decide whether to prosecute the individuals named in the reports. Dick Branzell, one of the eight FWS special agents called in for opening day at the marsh, said Sam Coons, an assistant U.S. Attorney stationed in Reno, told the agents to advise boat operators they were acting in violation of a federal court order and could be prosecuted for a felony, with a maximum penalty of one year in prison and a fine of $1,000.

The following day Nevada Senator Paul Laxalt said:

> Nevadans have had a bellyful of out-of-state groups trying to dictate policy in their state. Enough is enough. I'm going to try and stop it.
>
> I will propose legislation which will take the refuge out of the hands of the U.S. Fish and Wildlife Service and turn its management over to the Nevada Department of Fish and Game.
>
> This should help assure that the problems at the refuge are dealt with by Nevadans and not federal employees who may be well-meaning, but are nevertheless handicapped because they are subject to the whim of Washington bureaucrats.
>
> I also will offer legislation requiring that suits such as the one filed in Washington last week are in the future filed in Nevada, which will suffer the consequences of any court action.
>
> The wildlife should be protected, of course, No one quarrels with that. But the Fish and Wildlife Service, after listening to state and local concerns, had drawn up regulations which would have protected the wildlife habitat and still allowed some recreational opportunities for northern Nevada sportsmen.
>
> Once again Nevadans are being ripped off by a group of outsiders who present their problems to the more sympathetic ear of an eastern judge rather than come to Nevada and argue the matter face-to-face with Nevadans.
>
> That is a dastardly, evasive course of action, one that must be met directly. I hope the legislative remedies I am proposing will choke off some of these efforts to force unpalatable interference down the throats of Nevadans.

This example is but one of many reasons the men who are now attempting to take control of federal land have not been challenged by thousands of outdoor lovers.

What started out as a series of legitimate complaints against the federal land holders has now resulted in an attempted land grab by mining companies, large ranchers, land speculators, and oil companies. They have assured the truly injured residents of several western states that state ownership of land will remove all of the frustrations they have experienced in recent years.

A few vocal politicians have spent more time on the road espousing the values of the Sagebrush Rebellion than they have spent in the halls of our Nevada Legislature. These few individuals, I believe, are not entirely selfish, although some of them do graze their cattle on federal lands. They see their cause being every bit as pure as the search for the Holy Grail. They believe that state ownership of the 49 million Bureau of Land Management (BLM) controlled acres (20 million ha) in Nevada will give them control. Because of their legislative power they believe they will control grazing limitations, if any, and the great enemy called BLM will no longer be around to enforce or even advocate bothersome range management policies.

The eventual outcome of state ownership of all public lands would probably destroy many of the cattlemen now using these lands for grazing. Only the large corporate type ranchers would benefit because they would be capable of purchasing the land.

Somehow or another, this small band of legislators, not all of them from rural areas, has been able to convince their colleagues that state ownership of federally-controlled land will make everything right. They talk about making certain the land will not be sold off to private investors. They do this despite history showing the rapid disposal of state-owned lands in the West.

William C. Patric's study, "Trust Land Administration in the Western States," writes as follows:

> Through the years Nevada's state land policy has remained essentially one of disposal. Not only has this policy been unique with respect to the extreme degree to which it has been carried out, Nevada also is the only western state which has not reserved any mineral rights to the lands it has sold. . . . A Nevada research analyst estimates that the vast majority of the state's land was sold for as little as $1.25 an acre. At any rate, of the 2,723,647 acres finally granted to the state (not to mention the 1,864,000 acres waived in the 1880 deal), Nevada, as of 1980, held title to only 134,417 acres, of which only 2,591 acres seem clearly a remnant of its original grant.

In 1979, the new governor, former state attorney general Robert List, a veteran of several fights with the federal government, encouraged the legislature when they started to pour new fuel on the burning resentment toward federal actions in Nevada. The 1979 Nevada Legislature provided $250,000 to have the new attorney general start court action to take possession of the 49,117,667 acres (19,680,125 ha) presently protected by the Bureau of Land Management. They purposely left the Bureau of Reclamation and other more popular federal land holders out of the suit.

Attorney General Richard Bryan then took up the cudgel and promised to file a lawsuit the summer of 1979—later he changed it to the summer of 1980 and the rebels kept cheering wildly. Some legislators even came to the Nevada State Press Association meeting to tell how the land could be acquired in the courts. How well I remember three of them, not one an attorney, explaining how the "equal footing" doctrine would be applied and all of the land would have to be given to Nevada. They contended that Nevada had been treated unfairly by Congress when brought into the Union in 1864 and had to "disclaim all right and title to the unappropriated public lands lying within said territory." In other words, Nevada had not become a state under conditions giving "equal footing" with other states.

This line of reasoning conveniently overlooked subsequent acts of Congress in 1866 and 1880 which made more and better land available to the residents of the Silver State. Even more importantly, they did not take time to research constitutional law or Supreme Court decisions on the equal footing doctrine. The clearest decision was written in 1950 by Justice Douglas in *United States v. Texas:*

> The "equal footing" clause has long been held to refer to political rights and to sovereignty. . . . It does not, of course, include economic stature, or standing. There has never been equality among the states in that sense. *Some states when they entered the Union had within their boundaries tracts of land belonging to the Federal Government; others were sovereigns of their soil. Some had special agreements with the Federal Government governing property within their borders.* . . . Area, location, geology, and latitude have created great diversity in the economic aspects of the several States. *The requirement of equal footing was designed not to wipe out those diversities but to create parity as respects political standing and sovereignty.* (Italics added)

Needless to say, the U.S. Department of Interior solicitor did his research and told Nevada to step into the court room. After almost two years of legal fumbling, expensive lawyers, loud speeches and thousands of miles of traveling, all at the expense of Nevada taxpayers, the Nevada attorney general is yet to enter the court room.

Last fall's election saw Governor Ronald Reagan campaign in Salt Lake City and tell the West "Count me in as a rebel."

In January as President Reagan, he appointed the man who preceded me on the platform, James Watt, long known as a hired gun for business interests fighting to open up federal lands for their own use.

The vocal rebels see these successes indicative of things to come. They see the new Secretary of Interior fulfilling their desires with eventually all of the lands winding up in state ownership. Again they are to be disappointed because Secretary Watt knows this is not possible nor practical. He just happens to be a pragmatic administrator who will ease up on some of the present regulations now enforced on some federal lands. Some changes should be made and an even hand should be used in applying them. He is in a position to do little else at this time.

It is your job and my job to see that Secretary Watt and other guardians of our public lands do not dispose of them wantonly nor be unfair to the users of these lands. Users include ranchers, miners, sportsmen, etc. Yes, all of us who are fortunate enough to use the lands must be considered when regulators are overseeing the public lands of our nation.

The West needs land for expansion of many cities and towns. This can be accomplished, and has been accomplished in past years, through congressional action. Secretary Watt in a February 4, 1981 news release said.

> "One of my prime commitments as Secretary is my pledge to take into account the concerns and interests of the States as the Department makes its land management decisions. The action I am announcing today inviting the Governors, and through them counties and cities, to identify small parcels of federal administered land they want to acquire to meet community needs is an important step in honoring that commitment."
>
> Citing the case of a high school in Tonopah, Nevada, that waited 13 years for the Interior Department to issue a patent for less than eight acres of public land,

> Watt said: "There is no excuse for such bureaucratic delay. The community of Tonopah simply wanted the Federal Government to turn over enough land to give the high school an athletic field."

It is always good to hear about bureaucratic red tape being cut by a federal administrator. I might, however, make an addition to his press release to point out that the Tonopah baseball diamond was built very early in the process and only the formality of turning over ownership was slow—not the use of the ground. Also, all of the paperwork problems were not solely federal delays but some fault resided with the local government.

The original goals of the Sagebrush Rebellion are for all practical purposes legally dead, as it could never be accomplished successfully in the courts of our nation. It was, in fact, stillborn in the 1979 Nevada Legislature. However, the goals of acquiring your land and mine still glitter in the eyes of land speculators and potential landlords from many walks of life. They will now try to use political clout and their own bureaucratic maneuvering to take over this land and put it in the hands of people and institutions they can control. This we must prevent. This the public must be made aware of before they allow their politicians to spend one more taxpayer dollar to accomplish their subterfuge to lock up our land.

The feelings about federal mismanagement, in some cases affecting the people of the West, are still present and heated. This discontent has come from some real as well as imagined injustices. The answer is fair treatment, NOT the turning over of millions of acres of public land to state governments run by legislatures overly influenced by local and national special interest groups.

Even the Nevada Governor's Commission of the Future of Nevada saw through the so-called sagebrush rebels when it gave them their support. The commission showed its concern by adding some restrictions to all public lands acquired by Nevada. These included:

1. Adopt policies that the State will hold the public lands returned to the State for public use under multiple use concepts and not store them away nor dispose of them in a wanton manner.
2. Adopt policies whereby the administration of public state lands will be in an adequately funded State agency that will assume the basic functions of the present Bureau of Land Management as to range trespass, fees, permits, land sales, mineral entry, oil, gas, and geothermal leasing.
3. Adopt policies that will allow the use of land without unacceptable degradation.
4. Adopt policies that will insure public access to public lands.

What this group of prominent Nevada citizens told the rebels is that they want a voice in policies affecting their local governments and the disposal of land in their areas. They then demand policies the federal agencies oftentimes come under fire for enforcing. Most interesting.

Outdoors enthusiasts and all users of public lands have been fighting for years to keep the lands open for use by all. The records of many states show that they cannot be trusted with protecting the public's land. One of the most dismal records of not protecting the public interest in the disposal of land is held by my own state, Nevada. Nevada, the home of the Sagebrush Rebellion.

Northeastern Nevada is the home of key legislators pushing the grab for land. This same area has had several cases of private landowners charging sportsmen money to cross their land to get to public land. Can you imagine how additional large tracts of private land would adversely affect the use of what public land would be left over after the speculators and special interests had feasted?

Some changes must be made, but never should the public lands of our nation be turned over to governments that couldn't care for them properly even if they desired to do so.

That's your land and my land and we had better keep our eyes on it and make certain it will be there for future generations to use. To do less would be unforgiveable and an irretrievable loss recorded in the pages of future U.S. history books.

Perspectives on Energy Supplies and Demands

Charles J. DiBona
President
American Petroleum Institute
Washington, D.C.

It is a pleasure to address the largest and oldest conference on natural resource management in North America. Since you held your first conference in this city 45 years ago, competition for the use of America's natural resources has grown more fierce year by year. You have distinguished yourselves over those years as wise resource managers, and earned your reputation for professionalism in the many disciplines you represent.

In the decade ahead, your expertise will be in more demand than ever. This country will call on you to help strike a delicate balance between the important national goal of environmental protection and America's growing need for energy security.

It is the energy outlook for the United States in the next decade that I'd like to examine with you today. I'll discuss the progress that this country can make if some crucial decisions are made now. I'll also explore some of the implications that those decisions will have for natural resource management in the years to come.

The decade of the 70s was a kind of watershed for environmental protection in the United States. In those years it became clear that America had a critical choice to make. We could choose as a nation to continue in the ways of the past—to ignore the environmental consequences of rapid technological growth. Or we could take steps to reverse our course. We could resolve to preserve and protect our priceless environmental heritage.

The choice that Americans made in the last decade is familiar history. We committed ourselves as a nation to the careful protection of our environment. Congress enacted legislation to begin to correct past problems and to prevent future abuses. Already, significant and encouraging environmental progress has been made, and we look forward to future gains.

But while progress was made in some areas during the 70s, the U.S. lost ground in others. The same years that watched America break away from the environmental exploitation of the past also saw the U.S. develop a chronic dependence on foreign sources of oil—oil that was necessary to keep our homes heated and our automobiles, factories and farms running.

American oil use increased by about 30 percent in the last decade. All the additional oil we used—and more—came from imports. Those imports rose from about 3 million barrels a day in 1970 to about 8 million barrels a day in 1979. They came, for the most part, from countries half a world away—countries around the Persian Gulf or in Africa.

In those years we did not begin to import more oil because we had no energy left to develop at home. On the contrary, America was—and still is—rich in energy resources. But price controls on oil and natural gas discouraged domestic production. Controls kept more expensive energy sources such as synthetic fuels and solar power from competing with artificially cheap oil and natural gas. And controls encouraged consumers to use more and more oil and gas at comparatively low prices.

At the same time, environmental restrictions made it harder to produce and use domestic coal. Nuclear power was caught in a tangle of delays and government indecision. And millions of acres of public lands were closed off entirely from energy exploration. Thus, in the 70s we simultaneously stepped up our demand for energy—and shut down, at least in part, the production of energy from our own resources.

And so to fill the energy gap, America turned to foreign oil—oil which appeared to us then to be inexpensive. Only today are we finally learning—and paying—the real price for our dependence on someone else's oil.

That price has been substantial. First, imports cost Americans more and more money each year. In 1970, the U.S. spent around $4 billion for foreign oil. By 1979, the cost had jumped to almost $60 billion—an increase, in current dollars at least, of about 1500 percent. We have all felt the impact of that increase on our pocketbooks and on the nation's balance of payments.

Second, imports cost Americans continual anxiety about the possibility of future disruptions such as those that occurred in 1973 and 1979, when small Middle East oil cut-offs caused major supply problems in the U.S. The price for a severe disruption would be a crippled economy, radically altered lifestyles, and international crisis. Already, we have felt the impact of uncertain supplies of foreign oil on our pride and security as a nation.

Thus, a new decade brings us a new and important choice to make about the welfare of our country. We can choose to continue in the ways of the past—and become more and more dependent on foreign oil. Or we can take positive steps to reduce our dependence and become more self-sufficient.

The right choice to make about energy in the 80s seems to me clear—just as the right choice to make about the environment was clear in the 70s. Our goal as a nation must be to cut back imports substantially in the next decade and to begin to produce more and more—instead of less and less—of our energy at home.

In the past, many experts have predicted that the bad energy trends of the 70s would continue. But I believe that we can substantially reduce our nation's demand for imported oil—by as much as 50 percent from 1979 levels by the end of this decade. And, it is important to note, we can do this without turning back the clock and undermining the environmental gains of the 70s. I'll have more to say on this point later.

Several positive energy developments in 1980 give us hope that the trends of the 1970s can be reversed. The most striking of these was the dramatic drop in oil imports that took place last year when higher prices led Americans to conserve oil. The decline in imports of a million and a half barrels of oil daily was the largest year-to-year decline ever.

Of course, import cuts of such magnitude will not come every year. But there was a second promising development in 1980: an overall increase in oil production. This is partly the result of a larger flow of oil last year from the Alaskan oil fields than in previous years. Oil production in the lower 48 states has been declining for many years, but in 1980 the rate of decline also slowed to almost one-third the rate during the 70s. This is because we are able to drill more wells than ever before and produce more oil that was previously too expensive or difficult to extract, as prices reflect the rising value of our energy resources.

The upswing in U.S. oil production accompanied positive developments in other energy areas:

- Natural gas production increased in 1979 and remained just about steady last year.
- Coal production last year rose faster than predicted although the unexpected increase was due to higher coal exports and stockpiling, rather than to more coal use in this country.
- Companies developing synthetic fuels began moving from research and development toward commercial operations more quickly than expected.

Nuclear power's contribution to the total U.S. energy supply declined slightly in 1980. This was largely because the nuclear industry was still recovering from the 1979 accident at Three Mile Island. The moratorium on construction of nuclear plants has now been lifted, so nuclear power should begin to grow again next year.

The positive developments of 1980 offer us hope that imports can be cut substantially by 1990. Whether those cuts take place, however, will depend on decisions that the nation will be making in the next few years.

America must decide to use its energy resources fully if we are to reduce imports. There is no question that those resources are plentiful:

- American crude oil and natural gas resources are estimated to equal 40 years of production at today's levels.
- We have three times more coal than oil and natural gas.
- We have twice as much shale oil as conventional oil and gas.
- And we have enough uranium to sustain the nuclear power industry into the next century.

After more than a decade of growing environmental concern, it is clear that we can and must develop these resources responsibly.

Inevitably, however, our nation's efforts to reach the goal of energy security will conflict at some points with our efforts to achieve the equally important goal of environmental protection. In the decade just past, when those points of conflict became apparent, battle lines were often drawn. Bitter struggles took place in the courts, in the media and in the government itself. Frequently it seemed that one either had to be *for* energy and *against* the environment, or *for* the environment and *against* energy.

I hope that we have now moved beyond the polarizing rhetoric of environment *versus* energy. We have seen that the two need not be mutually exclusive. In the decade ahead, America cannot afford to have *either* a clean environment *or* secure energy supplies. We must have both.

Reducing oil imports does not mean that we must give up environmental goals. But we will need to be more realistic in the pursuit of these goals. If we proceed carefully and prudently, taking into account national, state and local priorities, the nation could soon be producing more of the energy we need here at home—and doing so in an environmentally acceptable manner.

To do this, we will need more energy from federal lands. These lands, including the Outer Continental Shelf, now provide only about 17 percent of the combined production of oil, coal, and natural gas in the U.S. Yet studies suggest that public lands hold roughly 40 percent of our potential oil, coal, and gas resources.

Many of these lands were locked away from energy exploration before we even knew their energy potential—and before we were aware of our need for the energy these lands might provide. The energy industry's experience with environmental engineering—much of it gained from working with those of you in resource management agencies—has made it possible to explore on these lands today with minimal disturbance. With proper environmental monitoring of such activities, Americans can be assured that every reasonable precaution will be taken in determining the extent of our energy resources on public lands.

In the decade ahead, we will also need a better balance between continued environmental progress and more energy production. In particular, the U.S. needs to take a careful look at the Clean Air Act. When this act was written, the causes of many air quality problems were not well understood. We did not know what air quality standards were most desirable, and little information was available about the methods, benefits, or costs that might be involved. Today, with more than a decade of environmental experience behind us, the U.S. needs to make reasonable and useful adjustments to the Clean Air Act. We can do this without abandoning the act's goals or jeopardizing our health.

America also needs consistent, timely government decisions about nuclear regulation—on issues such as fuel enrichment, waste storage, licensing and plant safety. And we must continue to allow the market to provide effective incentives for producing and saving energy. If Americans choose to support these steps, the U.S. could reduce oil imports significantly by 1990. That would give us more jobs, make us less vulnerable to OPEC price increases, strengthen our national security and justify confidence in our ability to control the future of our country.

To accomplish this goal, the environmental and resource development communities must make greater efforts to understand each other better. It is still possible that a large oil discovery, comparable to the Prudhoe Bays and the East Texas fields of the past, could be made in this country. But America's battle against dependence on imported oil in the end will be won or lost at hundreds of smaller energy projects around the country, from the oil fields of the Outer Continental Shelf to the tar sands of Utah. In the years to come, energy producers and environmental professionals can use each of these projects as occasions for confrontation. Or we can see them as opportunities for cooperation.

With pressing national energy problems, America simply cannot afford the delays, the waste of money and manpower, and the unnecessary bitterness and ill will that are the cost of confrontation. Different groups with different concerns do not inevitably have to be adversaries. In the decade ahead, environmental professionals and energy producers must meet at the planning table, not in the courts.

As many of you know, over the last 20 years API's Conservation Liaison Committee has been working to bring petroleum industry and environmental professionals together for discussion and exchange of ideas. For the last 10 years, API's Conservation Director Keith Hay—a man we drew from your own ranks—has directed that effort. He and I stand ready to work closely with you in the years ahead.

Together, I believe that we can begin to find rational and environmentally sound solutions to the energy problems that face this country. The national interest demands that we work with each other in a cooperative, professional way. To the extent that we do so, we will move toward a more secure, prosperous, and environmentally safe future for our country.

Effectiveness of the Corps' Resource Management Efforts

Lieutenant General J. K. Bratton
Chief of Engineers
Department of the Army
Washington, D.C.

I am pleased to be here this morning to participate in the 46th North American Wildlife and Natural Resources Conference. I hope, in some small way, to contribute some thoughts that might be helpful to you in your conference activities. As the Chief of the Army Corps of Engineers I wear several hats and answer to several bosses, both military and civilian. I might say, unlike Secretary Watt, I do not speak to the President every day. I hope, nevertheless, what I have to say today will be in line with the new administration's policies. No matter what boss I answer to—the bottom line is always resource management; and the Corps is judged on the execution of its mission by how well we manage our human and our funding resources, as well as those natural resources entrusted to our care or which are affected by our work. We are the nation's largest public builder and, therefore, we have special responsibilities to you and all the American people. We have a special mandate, I think, to make sure that by being the nation's largest public builder, we are properly cognizant of its resources and of its environment.

My remarks today will concentrate on the civil aspects of our work rather than the military. I have narrowed my talk to this one area because I believe it is the one of most interest to you, and also because I was warned against exceeding my allotted time. My words will be consistent with the new administration's policy, as I now know that policy with respect to water projects. It is essential that this be the case, and you would expect it since for our civil works program I answer directly to a politically appointed official, the Secretary of the Army. I might say, there has been no significant change that I have been able to detect from what I would have described as the Carter Administration policies, insofar as execution of our work is concerned.

It strikes me that compared to the life of our planet earth, we, men and women, have been around for a very short time. Moreover, we are totally dependent on the earth's natural resources for our existence. Nevertheless, in our short human history we have managed to clear-cut forests, convert wilderness to farmland, form a network of urban sprawl connected by ribbons of concrete, and consume a large part of the most accessible energy sources. We have opened and scarred the earth to exploit the energy source called coal. We have put waste on our land and into our air and water resources until they often cannot perform their natural ecological and life support functions. And, we have even built dams in rivers to provide electricity, water supply, and flood control for people who settled on the floodplains, and the prairies. While there have always been those who sought to limit exploitation and were concerned about our natural environment, it has only been in recent years that we have come to realize that our natural resources are indeed exhaustible and can be degraded beyond their natural ability to regenerate.

The proliferated consumption of and inroads into our natural resources have been done to meet the needs of modern society and national expansion, and we cannot turn back the clock or bring progress to a halt. But, we can analyze our consumption and our construction with a new awareness for the future and the need for wise stewardship of nature's resources. I certainly do not mean to imply that conservation or environmental imperatives should force us into a posture of no progress or curtailed development—but we are doing our work much more cautiously than in the past, and with a greatly heightened perception of the causes and effects of our actions.

The theme of this conference is "Resource Management for the Eighties." The Army Corps of Engineers is certainly going to do things in this decade—all directed and funded by your elected representatives—which will impact in some way on natural resources, and in particular those associated with water. Decisions will be made and physical actions taken that will affect all of us for a long time into the future. These are going on every day. The bulldozers are bulldozing and the shovels are digging and the dump trucks are moving dirt. How favorably or unfavorably our actions impact on our environment will depend largely on how skilled we are in achieving an enhanced water resource management infrastructure accompanied by enhanced assets. If something is consumed, something equal or better should be formed. That should be our philosophy all through this decade and beyond. We have reached the point where all our decision techniques must be sensitive to ecological processes and environmental values, based on a recognition that nature embodies resources of great intrinsic value that can only be overburdened or overtaxed at great cost.

In the years ahead the Corps will continue to design, construct, operate, and maintain major navigation, flood control, water supply, and hydroelectric power projects beyond the non-federal capability. Such water-related projects which can and often do include fish and wildlife enhancement as a project purpose should continue to accommodate future population growth and nurture economic well-being in the national interest. It will be a challenge to our leadership and management to see that this is done with total awareness of and protection for our natural environment. I want to assure this audience that emphasis is now on and will continue to be placed on water resource development and management techniques that incorporate non-structural methods, water conservation, ecological values, and social aesthetics throughout the planning and operational life of each project that we are directed to build.

Resource management is the heart and soul of a dynamic water resources program. I would like to share some aspects of what the Army Corps of Engineers has been doing to fulfill our responsibilities for water resource management. At the present time we have about six million acres (2,430,000 ha) of land and five million acres (2,025,000 ha) of water linked to some 430 projects. The Corps manages 4.7 million acres (1.9 million ha) for project operations, recreation, forest or range, and fish and wildlife. Three million acres (1,215,000 ha) are managed primarily for fish and wildlife, with the Corps directly managing about one million acres (405,000 ha) and other federal or state agencies managing the remaining two million (810,000 ha). Currently, more than 30 states have leased acres for wildlife management at about 200 Corps projects. This program offers no-cost land and water to other agencies, which they in turn use to fulfill local fish and wildlife management objectives. The degrees and types of fish and wildlife management programs vary from project to project and so does their effectiveness. Each project has its own master plan to meet individual management goals and expectations.

At some projects we only own a strip of land above the pool level or along linear stretches of river. At other locations we have large blocks of land within the project boundaries. We have some lake level fluctuations resulting from the flood control and navigation elements for which each project was designed. This fluctuation often presents a management challenge. It also produces some unique opportunities for varied habitat developments. For example, exposed lake bottoms can be, and often are, planted to grain to attract wintering waterfowl. Moreover, occasional over bank flooding provides some wetland-type areas, which are very popular with certain species of wildlife. In more recently constructed projects, there is minimum clearing prior to flooding, particularly in the upper reaches of lake areas, so the partially submerged timber and brush can provide favorable fish and waterfowl habitat. Other more traditional forms of wildlife habitat management include agricultural leases, planting food plots, timber thinning, nesting boxes, and strip cutting of brush. Also, selected and controlled water releases through our reservoirs have, in many instances, resulted in greatly improved downstream fishery development opportunities.

Our water resource development program faces the same lack of money and manpower the other agencies are experiencing, and pending reductions in our civil works program will, to some extent, impact on our associated fish and wildlife management program. We also are confronted with a sizable reduction in our federal manpower devoted to our civil works program which must be put into effect over the next 18 month period. This reduction exceeds 10 percent of our civil works force, and that's a sizable impact in any organization.

In light of pending reductions, I have stressed to our Division and District Engineers the importance of continuing wildlife management programs. I have asked them to distribute budget cuts which I am forced to pass on to them as well as the manpower reductions, to insure fish and wildlife management programs and other related environmental efforts receive no more than a proportionate share of these reductions. You have to keep in mind that in the past when we built something, the authorization for the construction of that project as we received it from Congress and for which appropriated funds were given to us was generally directed at some purpose other than environmental enhancement, recreation, and so forth. However, we willingly accepted these enhancement opportunities but they were seldom expressed as the primary purpose of the project as we were directed to do it by Congress. I see this trend changing to some extent in the future as we give equal consideration to national economic development and environmental quality during the planning of our projects consistent with the Water Resources Council's principles and standards.

Now, I said I would focus primarily on natural resource management rather than human resources, but I must say recreation management at Corps projects is an "experience" in providing water-related recreation opportunities to humans concomitant with protecting the natural resource base from overuse and degradation. We have concerns in this regard, but I only have time to touch on them this morning. About 450 million visits were made to Corps projects last year. This amounts to about 25 percent of the total recreation visits made to all federally owned areas. This also means that about 25 percent of the total visits take place on about 1.5 percent of the same federally owned lands. Our recreation areas are approaching the point where serious overuse is degrading the desirability and attractiveness of the areas.

Visitor use, or perhaps I should say overuse and misuse, is a problem to us as it is to other recreation managers. Destruction of the resource base and project facilities are commonplace. Recently the *Washington Post* ran a series of articles describing the substantial amount of damage being inflicted on national parks and recreation areas through deliberate vandalism, and oversaturation of motorized vehicles. I might add we have also encountered rowdyism and hooliganism. This was also the subject of a *National Geographic* magazine TV special. Our Corps projects are experiencing similar circumstances.

One of the challenges of the 80s is educating the general public on the proper use and care of recreation areas and the need to control the unruly visitor. We have rangers at all our recreation areas and of whom we are very proud. Generally they are young people who are trained in resource management, public relations, and ways to interpret the environment to visitors to their site. They are not policemen, and we do not want them to be. But it leaves us sometimes with the very difficult problem of enforcing what we think are reasonable rules and regulations established for the benefit of the public and not for the benefit of the Army Corps of Engineers.

Organizations like the National Wildlife Federation have done much to bring this matter to the surface through their media and public contacts, but more must be done. The problem confronts all segments of our society, both public and private. I recommend to this audience that every organization represented here today place this matter high on its list of national concerns and priorities. An inter-organization task force might be in order to formulate a strategy to create a national program on visitor use of public recreation areas.

Next, I want to talk briefly about our wetlands 404 program. I am particularly concerned about any speculation as to the future of the 404 regulatory program. There are no plans I know of to scuttle the program, but we do have to find ways to make it serve the public interest better. We have almost 900 employees across the country working full time simply administering the public program.

The current program has been built on a sandpile of laws, court decisions, and public opinion. Since 1968 we have had full public interest reviews of proposed activities, thus attempting to balance all aspects of public interest. Our wetlands policy recognizes that wetlands are a valuable and productive resource that requires special consideration. However, as you know, the 404 program is not a wetlands protection program per se, nor is it a land-use control program. This latter statement is the root of a recent court decision dealing with private property.

Last November the U.S. Court of Claims ruled in the case of the Deltona Corporation versus the United States that the denial by the Army Corps of Engineers of dredge and fill permits at Marco Island, Florida, constituted the taking of property without just compensation. The court concluded that permit denial so diminished the property value as to render it valueless for any purpose other than conservation. The Federal Government (Corps) may be given the option of rescinding the denial decision or paying compensation in an amount yet to be determined, but which is certain to be large. The claims court decision is being appealed to a higher court and the battle over Marco Island is far from over. However, this type of decision will have a profound effect on how we do our business of balancing economic development versus the value of wetlands.

Now, to make the program more viable, we need to find answers to a series of very significant questions. For example, since all wetlands are not functionally equal, how should we quantify the value or values of a particular wetland; what value criteria should be used to standardize the public interest review process on individual permit actions; and is the primary public interest national or regional, state or local, or is it preservation in lieu of energy exploration, farming, silviculture, and so forth. Another serious question is the wetland definition itself. There are several being used, just among federal agencies. In the Corps we are now looking at the multi-factor approach to determining wetland boundaries, using vegetation, soil, and hydrologic parameters as a basis for drawing the jurisdictional line. However, there seems to be no one set of criteria that will work in all cases. We therefore find it is necessary to do more research and site examination before we can fully use this methodology, which may in the long run prove to be the more scientifically sound approach.

I have asked Dr. Larry Jahn and the other members of my Environmental Advisory Board to devote their spring meeting to 404 wetlands questions. Hopefully, they will provide some answers that will help us improve the operational aspects of the program. Meanwhile we continue to receive requests for permits at the rate of about 20,000 a year, many of which are controversial.

Time does not permit me to discuss the full spectrum of Corps water resource development and management. But I will take another minute or two to mention our national hydroelectric power study and some of our environmental research efforts. We have published reports identifying some 2,100 federal and non-federal hydropower sites, including 469 existing federal dams. Also, we have developed and distributed hydropower feasibility study manuals for use by developers. I am convinced that our national goals of energy self-sufficiency or significant reduction in the nation's dependence on oil imports are achievable from the standpoint of technology. The real challenge is to meet these goals in a manner that will be harmonious with the environmental quality that we need to maintain. The Corps is obligated by law and in numerous executive orders to meet national environmental quality objectives while at the same time fulfilling its civil works mandate from Congress. We not only endorse the legal and administrative mandates but strive to exceed minimum requirements when and wherever possible.

The Corps strongly embraces the philosophy of environmental responsibility and is directing research to provide new or improved technology for planning, design, and operation of all civil works projects to achieve national environmental quality objectives in a manner compatible with authorized project purpose. Other research initiatives I will mention briefly are recreation carrying capacity, which is designed to get at our visitor use problems; and the development of a state-of-the-art wildlife management manual to provide consistent and proven management plans on those lands we now or in the future will manage for fish and wildlife. Another initiative concerns habitat evaluation methodologies to determine how to identify, quantify and use biological data in the planning, design, and operation of Corps projects. We have ongoing cooperative research with the U.S. Fish and Wildlife Service for development and field testing of habitat evaluation methodologies. Also, we have some independent studies which tend to complement development of these methodologies.

Traditionally, the Army Corps of Engineers has been labeled a development agency. We do not object to that label, but our responsibilities transcend those of most builders. We are in fact a resource management organization, and we do not drop our tools when the construction is done. The job is not finished. Our task is to manage what we construct in the broad public interest, and our goal is to insure that national economic development and environmental quality objectives are inter-supportive and compatible rather than competitive. No new project is proposed by the Corps without considering environmental concerns. Before recommending any design or construction for inclusion in the budget for the first time (what we refer to as a new start) projects are screened against such criteria as evaluation of benefits, costs, economic and environmental impacts and combined adverse effects.

While there are occasions on which unquantifiable benefits are given consideration, we still use an assessment of economic and environmental effects as the primary mechanism to judge the worth and advisability of proceeding with any project and we pass on recommendations and views on this basis up the line to Congress and to the President. In this manner, development and management of the nation's water resources can proceed and environmental goals can be attained while simultaneously achieving the goals of economic development, energy production and improvement in the overall quality of life. Obviously, tradeoffs will be necessary but they must apply to both sides of the equation: national economic development and environmental quality.

In closing, I want to wave the Corps flag just a little. We have two catchy mottos I am sure many of you have heard before. The first is "the Corps cares" and the second is "essayons" or "let us try." I hope I have conveyed my sincere convictions that I care and that the Corps cares as an organization about the future of our nation and the environment in which we live. From the Corps' perspective we see no retreat and no rollback from the progress or policies of recent years. And lastly, essayons—let us try. I submit to you that in the days and years ahead that we must all pull together to insure that the quality of life and the expectations we have as a people are met for our own welfare and for that of the future generations that will follow. I assure you that the Corps, as the nation's largest single builder, will be trying to do exactly that. Thank you.

Environmental Assessment: Gains and Challenges

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My topic this morning, "Environmental Assessment: Gains and Challenges," sounds fairly general and innocuous, heralding, one might reasonably suppose, merely another set of alarmist prognostications about the 1980s. The standard rap about the future of the environmental movement is glum these days, and the unhappiness seems to depend on some or all of three major heavies: Reagan, tight money, and the energy crisis.[1] The general theme, that industry's lust for energy supplies will undo the right reason of the last decade, may or may not be accompanied by related suggestions that the hen house is being guarded by a phalanx of salivating foxes or the idea that enthusiasm for federal regulation and federal expenditure has dried up, and environmental programs will wither where they are not directly dismantled. The major concern of environmentalists ought to be, according to this type of analysis, to hunker down and prepare to defend and protect the victories of the last decade. There is some truth in this new catechism. It provides two things we seem to need in American politics: (1) simple answers for complex questions or, perhaps treating it at its source, a journalistic lead for a story otherwise too long to tell, and (2) bad guys or devil theories with which to explain our problems.

The standard rap is standard primarily because it is simple. While not totally irrelevant, it is such a caricature of the problems that confront us that I have come to believe that, if we are to survive, and I am not sure either that we will or that we deserve to, we must reject it strenuously and explicity. It is too easy to blame Reagan, the Arabs, or the government. Most of our real problems I want to suggest this morning lie in the fact that we just do not know what the hell we are doing. Stated more formally, and in the context of the assigned topic, I can sum up my conclusions as follows: The major accomplishments of the last decade have been political; the major challenges which remain are technical or scientific. This generalization, which I shall modify only a bit in the text which follows, poses some difficulty for the rest of my presentation. I am a student of the American policy process and have no particular competence in general or specific sciences. I will, therefore, hedge my position a bit by identifying a major political challenge which remains. While I want to focus primarily on fundamental, technical problems, I am aware that they cannot be resolved in the absence of the political will and intelligence to do so.

I shall proceed first by attempting to define environmental assessment. Since the major difficulty with that term appears to stem from confusion with environmental impact statements, I shall do my defining largely by distinguishing environmental assessment from NEPA and the environmental impact statement process.[2]

[1]See, for example, P. Behr, "Overview: The End of an Era," 21 *Environment* 2 (November, 1979); C. Holden, "The Reagan Years: Environmentalists Tremble," 210 *Science* 988 (November 28, 1980); S. Duggan, "Whither the Environmentalist?" 2 *The Amicus Journal* 20 (Fall, 1980).

[2]For a recent analysis of the EIS process and a thorough bibliography of current literature on the subject, see R. Liroff, "NEPA: Where Have We Been and Where Are We Going" _*APA Journal* 154 (April, 1980).

Second, my explication of major gains of the "environmental decade" is based on a comparision of where we were at the beginning of the 1970s with where we appear to be now. Many problems which appeared overwhelming in 1970 are simply no longer important. Although I shall indicate there has also been critical progress in the science of environmental assessment, I shall allege these gains are also political—primarily solutions to personnel or institutional problems within the scientific community. Briefly stated, we have achieved public recognition of the fact that environmental costs and constraints must constitute a major component in personal, public, and corporate decision making; we have established a body of institutions, expectations, and laws which embody that awareness; and, finally, we have recognized environmental assessment as a field requiring public support. These achievements are important, and I have no desire to underplay their importance. However, I think we can read in the environmental lobbyists' and publicists' horrified reaction to the recent change in administration a tendency, understandable given the professional preoccupation of lobbyists and publicists, to overplay the political component of both environmental problems and solutions.

The third section of my argument will contend that, virtually untouched by the political developments in the environmental field—indeed obscured by the media hoopla surrounding the last 10 years—is the fact that we are only dimly aware of how to assess or understand the environment and the effect of human activities on it. There is hardly an issue for which we have proven concepts, indicators, measures, or criteria for meaningful environmental assessments. That, and not Reagan or energy, is the problem which confronts us in the 1980s.

The political challenge which accompanies this technical problem, I will argue in conclusion, is far more serious than we have encountered previously. We have built a movement and a complex set of laws and institutions on the constant reiteration of simple certainties: pollution is bad; nature is good. The challenge now is to sustain the commitment in the face of uncertainty and complexity and to adjust the movement, the laws, and the institutions to both our newly understood ignorance and to new realities as they emerge.

I. Environmental Assessment Approximately Defined

It should be obvious that, when I speak of environmental assessment, I am looking far beyond the vexing but relatively trivial problems of reducing the bulk of environmental impact statements.[3]

Environmental impact statements and the EIS or NEPA process have little or nothing to do with environmental assessment. EISs are not necessarily antithetical to environmental assessment, but they tend to be so—or at least to be unrelated—in past and current practice. Environmental assessment, for present discussion, consists of such things as understanding basic ecological systems and processes, identification and measurement of system response to change in the environment, prediction of short- and long-term effects of key changes, and identification of permissible levels of alteration and possible mitigation strategies. These tasks have little or nothing to do with EIS tasks such as "scoping" issues, identifying public

[3]Official response to the general unwieldiness of the National Environmental Policy Act (NEPA) process is codified at 40 C.F.R. Parts 1500-08, 43 Fed. Reg. 55978-56007 (11/29/78) and discussed in R. Bass and S. Warner, "Streamlining NEPA: A Look at the Council on Environmental Quality's New EIS Regulations," *Environmental Comment* 14 (August, 1979); R. Liroff, Supra, n. 2, passim.

concerns and preferences, or negotiating economic or political trade-offs. I associate environmental assessment with technical tools and concepts for understanding how human activities affect natural systems. They can be distinguished from political tools for decision making regarding specific discrete proposals. We seem to have confused understanding the ecosystem with writing political documents; and we are in danger of being misled into thinking that, because we are required to do the latter, we can meaningfully do the former. This is a tragic misrepresentation of our problems.

II. Political Gains in Environmental Assessment

In making that observation, I do not wish to denigrate the advances of the 1970s.[4] The previous decade has unquestionably been a period of tremendous success in the areas of political education and institution building. The major component of success in political education is that the question of environmental degradation—the cumulative effect of unanticipated, unnoticed, or seemingly unimportant changes in the environment resulting from human activity—emerged as a legitimate and important public concern.[5] There continue to be important gaps in this public awareness, and among the convinced there are inevitable differences in priorities and intensity of concern. Nonetheless, environmental issues came from almost nowhere, in terms of public visibility, to become a major part of the "fixed agenda" of problems which public, private, and individual decision makers must address.[6] This concept of a fixed agenda is, I believe, a central one. The fact that people recognize the energy-environment trade-off and appear, in some contexts, to prefer energy does not obviate the point that the environment is a concern which will be weighed in future policy choices.[7]

This is a significant change from the 1960s. Where we are today can be appreciated by reflecting briefly on the 1960s look at the environment. "Environment" was not much of a word then; to the extent that the topic was aired at all, it was publicly discussed in the general context of natural beauty. That was an era dominated by wilderness, urban recreation, and aesthetics. Lady Bird Johnson led the nation in a crusade to beautify by sweeping and planting. It was a start, and I do not wish to belittle the latter-day pioneers who pushed these issues to contemporary consciousness; but the gains of the last 10 years in the recognition of environmental degradation as an important problem have been phenomenal.

These advances in public awareness were accompanied by the development of

[4]Nor do I wish to digress into an evaluation of the importance of NEPA. My analyses have led me to a minority position on NEPA [see S. Fairfax, "A Disaster in the Environmental Movement," 199 *Science* 743 (1978); but see, also, S. Fairfax and B. Andrews, "Debate Within and Debate Without: NEPA and the Redefinition of the 'Prudent Man' Rule," 19 *Natural Resources Journal* 505 (1979).] I would define NEPA as a specious, intervening variable in most of the developments of the last decade; that is, I would argue that most of what I describe in Section 3 is a response to obvious and enormous public pressure. The elaboration of NEPA is one of many manifestations of that pressure rather than a cause or even an occasion for other environmental era phenomena.

[5]See G. White, 209 *Science* 183 (July 4, 1980), at 184-85.

[6]The notion of a "routine agenda," recurring issues to which a government must regularly attend is discussed in R. Cobb and D. Elder, *Participation in American Politics: The Dynamics of Agenda Setting* (1972).

[7]See, for example, E. Muskie, "The New Conservation," 2 *The Amicus Journal* 3 (1980) at 4, ambiguously citing a recent Lou Harris Poll as follows: [There may be a] change in one perception of environmental needs as other pressures vie for national attention. . . . a 54-31 percent majority of young people now believes environmentalists are making it difficult to find more sources of energy.' '

numerous kinds of institutions through which the emerging questions could be raised.[8] Developments in the legal field were most characteristic of the environmental era. As a result of a series of unusually pivotal Ford Foundation grants, a number of law firms specializing in litigating environmental issues were formed in the early 1970s. The Natural Resources Defense Council, the Environmental Defense Fund, the Sierra Club Legal Defense Fund, and a host of less-familiar outfits swarmed into the courtrooms to vindicate environmental plaintiffs' complaints. In this they were significantly abetted by two very much related institutional developments. First, the courts were generally responsive in the 1960s to a whole spectrum of pleas that they had historically considered beyond their jurisdiction. A noticeably activist court transcended what law professor Joseph Sax has described as "the mind-forged manacles of the law"[9] (most familiarly, barriers to achieving a standing to sue) and opened the courts to environmental litigants. Equally critical, the Congress was rapidly cranking out extensive standard setting and enforcement schemes for achieving clean air and water, controlling pesticides and hazardous wastes, and a host of other environmental goals.

The combined effect of the political education and the changed legal atmosphere of enforcement is interesting to note. Prior to the 1970s, there were roughly two ways in which a, for example, water polluter could be legally engaged. First, an aggrieved individual could call the pollution a nuisance or a trespass and sue the perpetrator to recover for damages inflicted on him personally by the polluter and the pollution. Second, the Army Corps of Engineers could proceed against the polluter under the 1899 Rivers and Harbors Act, not on the grounds that the pollution was undesirable as pollution but rather that it was a barrier to navigation. That is not intended to be sound legal advice, my point is that you could sue for nuisance, trespass, or for obstructing navigation; but efforts to control degradation of the water quality as such would not fit into the process. After 1972 and the Federal Water Pollution Control Act, the situation was dramatically altered. The question of environmental quality is recognized as legitimate, and institutions have been developed so that any individual citizen or group can press the matter in numerous forums.

Legal institutions are, of course, only part of the process. In government, virtually every unit added an "environmental" branch; and numerous line and staff agencies were developed to respond to the new set of policy problems. Most notable, perhaps, President Nixon created the Environmental Protection Agency (EPA) by Executive Reorganization in 1970 to insulate pesticide regulation from the conflicts of interest inherent in being housed in the Department of Agriculture among other things.[10] Almost immediately, Congress gave the new agency authority to administer and enforce a literally mind-boggling set of statutes for environmental protection. These laws would not have passed, moreover, without the sustained direction provided by proliferating and increasingly effective lobby and special interest groups concerned with environmental affairs.

[8] Actually, the issues *re*emerged, of course, from an earlier period in which the likes of George Perkins Marsh (*Man and Nature,* 1864) and John Wesley Powell (*Report on the Lands of the Arid Region of the United States,* 1878) tried largely in vain to interest their fellows in the unintended consequences of human action.

[9] J. Sax, *Defending the Environment* (1971) cn.S.

[10] See J. Whitaker, *Striking A Balance: Environment and Natural Resources Policy in the Nixon-Ford Years* (1976), Chapter 3 for a discussion of early EPA politics.

These institutions, public and private, are important for at least two reasons. First, what they do is obviously critical. Second, and less obvious, is that they constitute a tremendous reservoir of personnel whose primary concerns—and their jobs—depend on *perpetuating* the environment as an issue. Bunches of people—in federal agencies, private groups, community organizations and governments, corporations, legislative staffs, media and education—have a vested interest in sustaining the issue and its visibility.

All of this is fairly familiar. I have noted a few representative illustrations of a watershed era which we have all lived through in order to make the simple point that the major gains of the 1970s in environmental assessment were political. They were also fundamental. The whole topic of environmental assessment was literally born as a public issue; it achieved public recognition and acceptance; and, because institutionalized, is part of our fixed agenda of national concerns.

III. Technical Challenges in Environmental Assessment

The major point of my presentation is that the political accomplishments have obscured technical difficulties in the field of environmental assessment and that major future challenges lie in the sciences.

It would be nonsense, of course, to assert that we started from ground zero in the scientific area in 1970 or that no progress has been made in the last decade. Indeed, many of the gains in this area mirror those discussed above. For example, academic and research funding institutions, such as the more explicitly political agencies, have recognized environmental assessment as an issue and have begun to develop programs to train graduates who address these critical issues. I am not certain that all this is pure gain. Some of the trendier programs, even at major universities, seem aimed primarily at producing sensitive generalists. This is risky, I believe, and could contribute to the dilution of the technical disciplines with well-meaning sensitive people who are inadequately trained to critique or contribute to the evolution of the technical capacity we so sorely require. I say that having now taught in two such programs at two fine institutions. While my concerns are valid and important, they do not, however, undercut the basic gains in personnel development and institutional orientation.

However, while it is clear that the efforts of this growing cadre of environmental scientists have not been totally unavailing, it is also clear that we have made only a scintilla of progress in the direction of understanding ecosystems well enough to consciously minimize the harm our activities create. We began the decade—it amuses me to recall—with a proliferation of bumper stickers bearing the fundamentally unintelligible message "ECOLOGY NOW." The idea seems to have been that, if we would follow the laws of nature, everything would turn out fine. As I suggested previously, to the extent that the proliferation of environmental impact statements has suggested that we understand those "laws" or that they can make policy determinations, the whole thing has been a dangerous sham. We do not know the laws, and we do not know how to interpret what we do know.

Under the heading, "The Challenges Are Technical," I shall, in view of my limited scientific credentials noted above, speak in terms of personal experience in two areas—we do not know what we need to know, and, perhaps worse, we do not know what we think we know or assume we know.

Our ignorance in the face of what we need to know can be illustrated by experience with the Air Quality Act. The structure of the Act is simple, apparently reasonable: Congress authorized and required the EPA to identify air pollutants; set standards defining maxima which cannot be exceeded; and, in cooperation with the states, develop and enforce monitoring and abatement programs which will assure achievement of primary (public health) and secondary (welfare—property and ecosystem damage) air quality goals. It is my impression, however, that the whole program is intensely problematic. It is hard, where a substance is naturally present, to determine the level at which it becomes a pollutant. Once that level is determined, it is difficult to decide the point or points and appropriate times to measure for excessive concentrations. Should we monitor constantly at the theoretical tip of every smokestack? If not, where and when? There are no consistently applicable standards for determining where and when to monitor for what. We have the equipment to measure most air components to parts per million or per billion, but we do not know how to use that equipment in an effective monitoring program. Worse, we do not know how to interpret the data. We know something about short- and even midterm human impact of some levels of some pollutants but less about the combined impacts of several together and nothing at all about most pollutants and how to measure and establish their long-term impact on either humans or on the environment.[11] As to setting permissible levels and achieving them, our programs are controversial because our understandings are primitive. I am not talking about obvious and unavoidable problems in deciding, once the basic data are at hand, how much health impairment or hazard is tolerable or how much effort and money to invest in order to achieve how much reduction of risk. We talk in those terms apparently to make the point that those balking at the regulatory framework are callous bastards valuing private profit over public health. There clearly *are* people like that, and we must deal with them. However, at present we do not reach that question—we simply do not have appropriate measures or criteria, and pretending otherwise is not helpful.

It is probably not surprising that we are not totally on top of air pollution problems. Although we have been polluting for centuries, we have only relatively recently gotten beyond smoke abatement in our dealings with the issue. Indeed, we are still busy inventing the pollutants. Less understandable is the fact that we also have appalling knowledge gaps in areas with which we are ostensibly intimately familiar. I shall relate briefly to my observations of the Wild and Free Roaming Horse and Burro Committee of the National Academy of Sciences to suggest my meaning. I sit as part of that Committee, humble and quiet, mindful of the fact that I am a "soft" social scientist in the presence of range ecologists,

[11]Measurement problems—deciding what to measure, where, when, and how, and then deciding what the data means—are endemic in virtually all of our recently enacted regulatory schemes for environmental regulation. The Cairns report details measurement problems under one narrow segment of TOSCA (Toxic Substances Control Act). See Committee to Review Methods for Ecotoxicology, *Testing for Effects of Chemicals on Ecosystems*, National Academy of Sciences, 1981. For a more general assessment of TOSCA related problems, see J. Walsh, "EPA and Toxic Substances Law: Dealing With Uncertainty," 202 *Science* 598 (November 10, 1978); and B. Culliton, "Toxic Substances Legislation: How Well Are Laws Being Implemented?" 201 *Science* 1198 (September 29, 1978). More generally on measurements as a stumbling block to understanding *and* regulation, see J. S. Hunter, "The National System of Scientific Measurement," 210 *Science* 869 (November 21, 1980).
I am more grateful to my colleague, John Harte, of the Lawrence Berkeley Laboratory, University of California, Berkeley, for helping me think about and document the points in this section and more generally.

geneticists, wildlife biologists, animal behaviorists, and other types who really *know* what they are talking about. We gather to define research that will tell the Bureau of Land Management (BLM) how to deal better with the horses and their impact on the range. I was stunned to learn that, although there is an enormous literature on a few species, there is almost none on most others. And there is little or nothing at all on how the species and the land, climate, and vegetation fit together into an ecosystem. There is, for example, crude information on overlap of some species but no commonly used definition of interspecies competition and not much data relevant to the definition that is accepted. Except for a very few species, we do not know what they eat, or prefer to eat under what circumstances; or why they prefer it; or how it nourishes them; or even how to figure out those things accurately.[12] Although we recognize that the little critters—bugs, birds, rodents, and others—are an important part of what is out there, we know very little about them and how they fit in with each other and the "real" wildlife which is being managed.[13] We have a lot of hearsay decrying the horses' effect on cows or bighorn sheep and virtually no conclusive data with which to answer the basic question, "Do they compete?"[14] Never mind determining how much or with what ramifications or constructing a primitive understanding of the range ecosystem now allegedly stressed by proliferation of ostensibly wild horses. As to understanding the real questions we must ultimately deal with—such as what is happening to an ecosystem subjected to the potentially hazardous combination of air pollution, water pollution, horses, cows, and BLM land management—we write impact statements; but we do not know what is going on.

IV. Conclusion

I will close with a few hypotheses on what I see as the problems inherent in this combination of successful advocacy and primitive scientific understanding and where that ought to head us in the future.

We have passed a lot of problematic laws—technically unsound and, therefore, potentially counterproductive to the goals they pursue. I will give you some quick examples. The Endangered Species Act mandates a rather rigid, nondiscretionary single variable set of habitat management criteria which, if pressed, are not only politically inflammatory but also make no provision for ecological succession of the habitat, the presence of two or more endangered species, or the general health of the ecosystem as a whole.[15] In a different area, the 1977 Amendments to the Federal Water Pollution Control Act, in a laudable attempt to reduce the amount of water required to cool steam electric power generating plants, require that wet cooling towers be installed in absolute preference to the apparently less water efficient practice of "once through" cooling. This mandate fails to evaluate the return flow from once-through cooling where the process of which *diverts* more water than wet cooling but because it loses none in evaporation actually *consumes* less. Rigid requirements, though well intended, may simply foreclose choosing the optimal technology in a specific situation.[16]

[12]Committee on Wild and Free Roaming Horses and Burros *Phase I Final Report,* National Academy of Sciences, 1981 at 142-43; 161-65; 237-38.
[13]*Ibid.,* 236-44.
[14]*Ibid.,* 241.
[15]S. Dana and S. Fairfax, *Forest and Range Policy,* McGraw Hill Book Co., 1980, at 261-64.
[16]Harte and El-Gasseir, "Energy and Water," 199 *Science* 623 (February 10, 1978), at 628.

I am not, by the way, saying that these laws should not have been passed, that the opponents are right, or that they ought to be repealed. In the heat of battle, advocates must take what they can get support for, and they must work rapidly to exploit their moments of public visibility in order to maximize their eventual standing in the fixed agenda. What I *am* saying is that it would be a tragic error to view the coming years as merely defensive in which the forces of light must hunker down over their jewels and resist questioning and change. The simple slogans and crude insights of the 1970s must remain flexible—to admit error as it becomes apparent and to adapt to new information as it develops. These are risks in the political gains I have described. We have institutionalized a lot of ignorance, a lot of best guesses which have turned out to be wrong, and a lot of single-purpose goals which are not harmonious with sensitive ecosystem management. We may want to abandon them. But even as I do not see the general posture of defensiveness as appropriate, I do not see my own argument as a counsel of retreat. This is a time, in my opinion, for sorting creatively and positively among the confusing array of assumptions and guesses that underly our complex regulatory network and beginning to seperate the wheat from the chaff. It is also a time, I believe, when aggressive political action is required to sustain and expand our research capabilities. Generally, I look upon calls for more research from academics with the same respect with which I regard calls from generals for more bombs. I do absolutely no basic scientific research, however; and, therefore, I am not arguing—even obliquely—in my own behalf. I simply believe that, if we do not follow up our decade of political learning and institution building with a serious and sustained national commitment to understanding fundamental bases of the issues we have raised, we will not only have struggled in vain in the 70s but we also put civilization, the human race, and the environment we seek to protect at peril.

Improving Management of Migratory Birds

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Evaluation of Stabilized Season Lengths and Bag Limits for Hunting Ducks in the United States and the Prairie Provinces of Canada

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Introduction

A five-year program of stabilized hunting regulations (season length and basic bag limit) for ducks was initiated on an experimental basis in western Canada in 1979 through the joint efforts of the Canadian Wildlife Service (CWS) and the Provinces of Manitoba, Saskatchewan, and Alberta. A similar program was initiated throughout the U.S. in 1980 by the U.S. Fish and Wildlife Service (FWS) with the idea that there would be a joint U.S./Canadian evaluation effort. The concept of stabilized regulations, jointly implemented and evaluated by the U.S. and Canada, received support from the Flyway Councils and other organizations that recognized the mutual benefits to be gained by a coordinated international approach.

During the past two decades, there has been a continuing interest in Canada and the U.S. toward developing a unified approach to defining and solving waterfowl management problems. Initially, most attention was directed to problems in production areas where the effects of habitat destruction and deterioration on waterfowl populations were most obvious, but recognition of wintering areas soon followed. A consensus regarding the causative factors of these problems was not reached, but studies were initiated to develop habitat-oriented management programs to counter the long-term effects of habitat loss and deterioration in both breeding and wintering areas. More recently, a 1976 publication, describing relationships between hunting mortality and annual survival of mallards, raised doubts about the effectiveness of earlier management strategies wherein hunting regulations were deemed the most important element in controlling waterfowl populations. It is apparent that we need to know much more about the nature, magnitude and sources of waterfowl mortality and their impact on specific populations.

Stabilized regulations are part of a cooperative CWS-FWS effort to evaluate the effect of hunting regulations on duck harvests and populations, and to develop a better understanding of the factors which regulate duck populations. The evaluation program described here will require initiating new studies and redirecting ongoing work to accomplish the stated goals. It is intended to provide information which will allow: (1) determination of the degree to which annual duck harvest is influenced by population size, species composition and age structure; (2) assessment of the impact of land-use policies and practices, and management strategies on waterfowl populations; and (3) guidance for determining future research and management programs on both the breeding and wintering grounds.

The evaluation described here is separated into 2 categories:

1. those activities that are necessary to gain a better understanding of how hunting regulations, hunting conditions and waterfowl abundance affect hunter activity and the size and distribution of the harvest; and
2. those activities that are necessary to gain a better understanding of the relationship between waterfowl populations and habitat availability and use.

Overall, it is expected that the information resulting from the program will provide an improved understanding of how hunting regulations relate to other factors affecting the abundance and distribution of waterfowl in North America.

In the past, considerable research and management effort has been directed toward mallards, including extensive analysis of banding and recovery data, and detailed interpretation of harvest surveys. In this program, the mallard will continue to be a key species because of its abundance, wide distribution and importance in the harvest. However, attention will be given to some other species that are of management concern such as black ducks and canvasbacks. The FWS and CWS have already initiated new banding plans for the next 5 years that include winter and preseason programs for mallards and black ducks, and a winter program for canvasbacks.

Proposed Program

Harvest and Hunter Activity, Hunting Conditions, and Fall Flight

In previous years, efforts to describe the effects of various regulatory actions in terms of the resulting harvest have not been entirely satisfactory. Principally, the findings have been confounded by hunting regulations that have been adjusted to varying degrees each year to correspond with the anticipated size of fall duck flights. These adjustments have also hindered an assessment of the effects of regulations, through changing harvest levels, on subsequent breeding populations and fall flights. The objective of removing annual variation in regulations is twofold: (1) to improve our ability to evaluate a particular set of regulations in terms of annual harvest levels, and (2) to provide a more accurate evaluation of the relationship of annual waterfowl harvests to fall populations. The following program descriptions outline activities, some of which are currently operational, that are necessary to (1) monitor changes in harvest levels and hunter activity on an annual basis, and (2) provide better information on the mechanisms by which waterfowl populations respond to particular levels of mortality during the hunting period. Overall, the stabilization of season lengths and bag limits will present opportunities for assessing characteristics of the duck harvest and hunter activity in relation to particular hunting regulations, hunting conditions, and fall population levels.

1. Measures of Harvests and Hunter Activity

Both the FWS and CWS have ongoing survey programs designed to measure annual waterfowl harvests and obtain information about waterfowl hunting activity and success. In the United States, the Mail Questionnaire Survey was initiated in 1952 and the Cooperative Waterfowl Parts Collection Survey was initiated in 1961. The National Harvest and Species Composition Surveys in Canada were begun in 1967. Each year, survey data are obtained on total duck kill; species, sex, and age composition of the kill; and the chronological and geographical distribution of the harvest. These important harvest characteristics will continue to be monitored to determine how they are affected by hunting activity, the size and structure of fall populations, and hunting conditions while season length and bag limits remain constant. Generally, this analysis will be similar to that conducted by the Pacific Flyway Council to evaluate their stabilized regulations experiment during the 1975-79 period.

In Canada, systematic hunter observations, field interviews, mail questionnaires, and telephone surveys are providing information on actual kill, unretrieved kill, illegal kill, and reported kill. These data will be important also for testing relationships between regulations and the harvest in conjunction with stabilized regulations. Furthermore, they hold promise to clarify some aspects of information reported by hunters participating in the Canadian waterfowl harvest surveys.

The FWS has long recognized the desirability of improving the sampling methodology associated with harvest surveys in the U.S. An improved system would provide a more statistically refined sampling frame of waterfowl hunters, and make the estimates compatible with those harvest statistics presently obtained in Canada by the CWS. Consideration is being given to various alternatives for improving the system, but it is unlikely that changes can be implemented in time to contribute significantly to this evaluation.

2. Mechanisms of Population Response to Waterfowl Harvests

Several ongoing programs (May breeding population surveys, July production surveys and preseason banding operations) are designed to provide information about waterfowl population status and fall flight. Due to the differences in breeding chronology of the many species involved, it is difficult to obtain information that will pertain equally to all waterfowl during a single survey. Recruitment varies among the various geographic areas in relation to local habitat conditions and the species of ducks involved, and the present aerial surveys do not provide detailed information about recruitment from specific areas. Additionally, the information presently available concerning the proportion of the population observed in the early spring that survives until fall is not adequate to estimate fall flights with a high degree of accuracy. Consequently, during the period of stabilized regulations an effort will be made to improve some ongoing surveys and field activities, and to supplement them with additional programs designed to furnish a better assessment of fall populations.

a. Breeding Ground Population Inventory. The Waterfowl Breeding Ground Survey program was revised in 1973. The number of air/ground comparison transects was nearly doubled from 32 in 1973 to 58 in 1979 in order to provide more accurate and representative estimates. We plan to conduct additional ground surveys of breeding pairs along a subsample of the established routes in Prairie Canada and the North Central U.S. at intervals of 4-5 days. These surveys will provide an improved assessment of the chronology and extent of breeding on these areas.

b. Spring/Summer Survival. The breeding period represents a critical portion of the annual cycle for waterfowl. Our efforts to monitor waterfowl on the breeding grounds in the U.S. and Canada have been confined mainly to measuring population fluctuations of breeding birds in the spring and brood production indexes in the summer. However, additional work needs to be focused on the breeding period, especially with regard to the timing and extent of factors such as natural mortality that impact directly on reproductive efforts and subsequent fall populations.

Recent studies have indicated that hunting mortality in mallards is generally compensatory. If this is so, some form of density-dependent mortality must occur during periods when resources are limited. Investigations on block study areas in Prairie Canada indicate that the proportion of female mallards successful in rearing a brood has declined during the past three decades. These results imply that availability of suitable nest sites and predators may now have more impact on duck populations than they have had in the past. Age and sex-specific estimates of annual survival are now being obtained for certain waterfowl species from expanded banding programs in the U.S. and Canada. The approach recommended here is one designed to partition survival into seasonal components, and focus attention on the effect of breeding season mortality on reproduction and fall flight.

Although radio telemetry has been used successfully in similar studies elsewhere, it is not recommended in this case because the cost and manpower would be prohibitive. Consequently, we propose intensive spring banding to furnish recovery and recapture information that can be used in conjunction with preseason banding to derive breeding season survival estimates. In each of five Province and State areas, emphasis will be placed on meeting banding quotas for adult females and locally-produced birds. Recovery information from adult females banded in the spring will then be used with similar information from preseason-banded birds to obtain estimates of survival during the breeding season. This banding and recovery information will also furnish a better understanding of the distribution and derivation of the waterfowl harvest. Further, an index of harvest rate, calculated from estimates of total harvest, spring population size and summer survival, will be used to evaluate the relationship between hunting mortality and annual survival.

c. Recruitment Studies. Although extensive in nature, the current Production Survey provides only limited information about recruitment of waterfowl by species. Efforts to corroborate aerial data with ground surveys have been unsuccessful for a variety of technical reasons. Presently, the most meaningful data gained from the Production Surveys are the late nesting indexes and numbers of July ponds.

In 1978, the CWS implemented a program to monitor prairie duck recruitment and to determine the impact of land-use change on duck production. Efforts to monitor recruitment on these areas were successful, but efforts to determine relationships between land-use and recruitment were not.

In conjunction with other aspects of this evaluation program, we propose that recruitment studies be increased in their scope but directed away from the present block study sites and toward the more extensive roadside transects. Waterfowl breeding pair and brood counts will be conducted every 9-10 days throughout the production period along selected air/ground survey routes to develop production indexes, following procedures recently developed at the Northern Prairie Wildlife Research Center. This information will allow a more complete assessment of waterfowl recruitment for particular geographic areas on the breeding grounds. In addition, this effort will provide specific data on sex ratios and nesting chronology. The relationship between these specific recruitment indexes and the results from the Production Survey will enable an evaluation of the current survey program.

Waterfowl Populations and Habitat Availability and Use

It is anticipated that the program for evaluating stabilized regulations will provide an opportunity to apply and extend waterfowl research and management to address current needs. In addition to the more basic aspects described previously, there are other key areas of concern which should be addressed in order to gain a better understanding of the regulation of waterfowl numbers. Included in this portion of the overall program are activities to:

1. determine the extent of waterfowl mortality during the wintering period;
2. obtain better information on waterfowl numbers and distribution on primary wintering areas;
3. identify and quantify the primary habitats on the breeding and wintering grounds and the factors that govern their importance and use by key waterfowl species;
4. determine the effect of environmental changes, including drought and various land-use practices, on waterfowl during the breeding and wintering periods.

The following activities will require the talents and interests of both researchers and managers. The result will be a strengthened waterfowl program in both Canada and the U.S.

1. Winter Survival

The winter period may be a critical time for waterfowl populations. This is especially important in view of the fact that these birds are concentrated when many required resources may be limited. The present level of knowledge about the effect of various mortality factors on waterfowl populations during this short, but extremely important, period is insufficient. Information from banding sedentary wintering populations of ducks during late fall will be used with similar information from winter-banded birds to obtain interval survival rates for the December-February period. We recommend that this effort be concentrated in the

Mississippi Delta region.

Consideration of survival rates and sources of mortality during the wintering period will increase our understanding of the population regulation of certain species of ducks and thus assist us with regard to management decisions based on population size and structure. This information will provide guidance for future decisions relating to protection and management of particular wintering areas.

2. *Winter Population Inventory*

As studies of key species of ducks are extended to the wintering periods, it will be necessary to complement these programs with population survey data. Since the 1930s, waterfowl populations have been inventoried on wintering areas of the United States. Generally, these surveys have furnished indexes to relative abundance and distribution of waterfowl annually. However, in the present experimental program, efforts will concentrate on developing a sampling scheme for the winter period that will allow more accurate determination of population levels of key species and improved comparability of the estimates from year to year. We propose to direct these efforts toward black ducks and canvasbacks in the marshlands of coastal New Jersey and Chesapeake Bay. In the Mississippi Delta and the Central Valley of California, population surveys will be directed toward the mallard. Techniques such as line transect sampling and aerial photography will be considered for application in these latter areas. Changes of duck numbers relative to weather and habitat conditions will be of primary importance.

3. *Habitat Inventory*

a. Breeding Grounds. The breeding requirements of waterfowl and the extent to which moisture regimes affect the distribution of ducks have been the objectives of considerable investigation. For example, both FWS and CWS investigations have furnished information on densities of breeding waterfowl and pond preference on selected study blocks. In addition, recent radio-telemetry studies have indicated nesting habitat preferences for the mallard. Overall, these studies have underlined the need for current information regarding the quantity and distribution of semipermanent and permanent wetlands in Prairie Canada and the North Central United States.

Past efforts to inventory nesting habitat have relied heavily on instantaneous surveys. To date, a satisfactory remote sensing application, including satellite imagery, has not been developed. Satellite techniques lack the resolution to count small wetlands, and aerial pond counts cannot provide the detailed information to assess adequately the status of prairie and parkland breeding habitat.

One obvious requirement is for a habitat survey that will provide information on the availability of preferred wetlands and a measure of nesting and brood-rearing habitat over the breeding range of waterfowl. Present air/ground transects provide an initial sampling frame for collecting these data on a prairie-wide scale. This program could be expanded later to encompass breeding areas outside the prairies, depending on results from the preliminary studies.

We propose to photograph these transects as soon as possible and collect baseline data on each pond to provide a basis for future studies. Subsequently, estimates of the extent and type of suitable wetlands and nesting habitat available to prairie ducks each year can be developed.

Another important aspect of breeding ground habitat evaluation is to determine the rates of change in the number and distribution of breeding habitats in association with land-use practices. In 1976 the CWS modified the collection of habitat data on air/ground transects to assess the impact of land-use on waterfowl breeding habitat. These surveys yield valuable trend information but lack the precision needed to predict the impact of progressive deterioration. In 1979, intensive habitat surveys were implemented to document rates of nesting habitat loss on quarter sections associated with the air/ground transects. However, this intensive program has been restricted in scope, because of its extensive labor requirements. Furthermore, it has been subject to the human interpretation errors inherent with onsite surveys.

As part of this long-term approach, it is expected that CWS and FWS survey personnel will continue to collect the trend information on land-use. However, the quarter-section approach should be deferred and replaced by more precise and representative procedures associated with the aerial photography described above. Specifically, we propose that, following the collection of baseline data, aerial photographs should be taken along these transects of Prairie Canada and the North Central U.S. during both May and July of each year. From these records, the rate of change of pond numbers by wetland type will be available directly, including differences among years and between seasons. In addition, data relating to changing land-use practices and subsequent loss of critical upland cover around these wetlands will be available for yearly comparisons.

b. Wintering Areas. The influence of winter habitat conditions in the life cycles of different species of waterfowl is poorly understood. Little information is available concerning the status and trends of winter habitat as well as the habitat requirements of key waterfowl species during the winter.

Any long-term wintering ground study should begin with an inventory of the quantity and quality of habitat that exists today on the wintering areas of the U.S. Wintering habitat is being rapidly lost because of drainage, land-use changes, pollution, and increasing urbanization. Consequently, it is necessary to develop baseline data on important wintering areas, including coastal marshlands, floodplains, bottomlands, flooded farmlands, and small watersheds.

The National Wetlands Inventory initiated in 1975 will provide baseline information on the classification and extent of wetland areas in the United States. Accordingly, we propose that this inventory be updated annually from satellite imagery on principal wintering areas, including the Columbia Basin, Central Valley of California, Gulf Coast, Mississippi Delta, and the mid-Atlantic Coast. These surveys will furnish data on wintering habitat of waterfowl, especially the amount available, rates of change, and associated land-use.

4. Associated Research Activities

a. Breeding Grounds. The indicated reduction in recruitment in prairie-nesting mallards suggests that destruction of nesting cover may be adversely affecting many of the early nesting duck species in the prairies. We propose to accelerate research into determining how changing land-use practices influence prairie duck recruitment. Efforts should be directed to the identification of factors that influence land-use practices and investigation of alternatives for land-use. Finally, recognizing that these practices are in response to economic incentives, we propose to conduct a comprehensive study of the relationships between various land-use practices and agricultural production, including cost-benefit analyses.

b. Wintering Areas. The winter period is characterized by large concentrations of waterfowl in relatively small areas. Various factors such as food, habitat quality and availability, and weather may be limiting to ducks, and competition for limited resources may be severe in some areas for certain species. Consequently, attention needs to be focused on the impact of these factors on wintering waterfowl populations, especially with regard to the relationship between the timing and extent of natural mortality following the hunting season.

Investigations should focus on the key features of each habitat type including physical, chemical and biological characteristics as well as changes in duck numbers on these areas over time. In addition, the relationships between habitat characteristics and food allocation and utilization should be determined, especially with regard to the preparation by waterfowl for northward migration and breeding. Knowledge of habitat requirements for wintering waterfowl will allow evaluation of the impact of habitat change on the waterfowl resource.

The Mississippi Delta, the mid-Atlantic Coast, and the Central Valley of California are prime areas of consideration for these research activities. Presently, the FWS and others are involved in an intensive program involving habitat assessment, food resource availability and use, and bioenergetics for the mallard on selected areas of the Mississippi Delta, and we propose that these efforts be expanded to include the Central Valley of California.

We propose that the black duck be included in these activities because of the need for an improved understanding of its status and population dynamics. Since preseason banding quotas may be difficult to achieve for the black duck in some areas, we recommend that the intensive post-season banding efforts in the mid-Atlantic Coastal area (New Jersey) be continued to obtain improved annual survival estimates. Additionally, we propose that banding and marking operations of canvasbacks, as well as food habits and bioenergetic studies, which have been underway for several years, be continued in the important wintering areas of the mid-Atlantic Coast. These activities will not only furnish survival characteristics for a large wintering segment of the canvasback but also monitor the value of these wintering areas to the species.

Summary

Waterfowl represent an important renewable natural resource in North America and, at various times during the annual cycle, these migratory bird populations reside or pass through nearly all parts of the continent. In the last decade, concern for waterfowl populations has increased significantly, especially with regard to continued habitat deterioration and loss of prime nesting, staging, and wintering areas. This concern has precipitated a series of proposals and programs aimed at addressing these problems.

The program of stabilized regulations was developed to provide an improved basis for evaluating the effect of hunting regulations on duck harvests and populations, and to provide an opportunity to develop a more thorough understanding of the factors which regulate duck populations. This program will allow waterfowl researchers and managers to obtain much-needed information on the dynamics of representative duck species throughout the year. A significant portion of this program is directed specifically at evaluating the relationship between the size and distribution of the harvest, hunter activity, and duck population levels during a period of time when major regulatory elements are maintained at a constant level. In addition, we have proposed a series of research and management activities associated with critical areas of investigation as they relate to waterfowl throughout the annual cycle. With the information that is gathered, we should be able to better understand not only what is happening to duck populations in North America during an experimental regulatory period, but more importantly why such changes, if any, are occurring.

We have attempted here to underline the importance of an intensive banding and marking program which will enable us to partition survival into seasonal components and conduct a more thorough examination of the effect of mortality (natural and hunting) on waterfowl populations. In addition, the proposed studies of recruitment should permit calculation of indexes of duck production for separate geographic areas. This would be an improvement on existing generalized methods that apply only on a continent-wide basis for ducks as a whole. The identification of factors associated with habitat availability and preference will assist in managing and preserving areas vital to the welfare of these migratory birds on both breeding and wintering areas. These studies will involve not only the identification of the chemical and physical elements that typify particular habitats, but also the biological aspects that govern duck selection and use. Finally, we hope to ascertain a basic understanding of land-use practices and their effects on the status of waterfowl populations.

This evaluation program presents an opportunity for Federal, Provincial, State, and private organizations and individuals to cooperate and contribute to a better understanding of the present status and future needs of migratory waterfowl. We feel that the program outlined here will contribute significantly to preserving and protecting migratory waterfowl in light of increasing environmental changes and human demands in the future.

Do Wetland Conditions in the Mississippi Delta Hardwoods Influence Mallard Recruitment?

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Mallards *(Anas platyrhynchos)* are widely distributed in the Holarctic where they are the most abundant anatid and are harvested in greater numbers than any other duck (Bellrose 1978). Because of their abundance and importance as a harvested species, state and federal agencies as well as private organizations have invested heavily in research, management, land acquisition, and wetland developments and easements. Research has usually addressed migrational movements and pathways, behavior, and breeding biology. The belief that harvestable mallard populations are dependent primarily on breeding ground conditions and breeding populations undoubtedly led to this research emphasis (Pospahala et al. 1974).

Between 1946 and 1947, numbers of breeding ducks were far below the carrying capacity of breeding habitats in southern Manitoba (Hochbaum 1947). Over-harvest of local birds on breeding sites was suggested as the most likely factor but destruction of breeding habitat was also recognized. More recently, Trauger and Stoudt (1978:199) indicated a scarcity of breeding birds on wetlands in the prairie provinces and suggested that factors outside the breeding grounds may affect waterfowl populations. Even though mallards spend far more time on wetland areas not directly associated with breeding, our understanding of how these non-breeding habitats affect mortality and productivity is meager.

Seasonal environments and food resources play an important role in controlling bird populations (Fretwell 1972). Remarkably little is known about nutritional requirements of waterfowl during winter or migration (Fredrickson and Drobney 1979, Prince 1979). We have assumed that wintering areas were not limiting, that winter foods and condition played little or no role in the subsequent reproductive phase, and that waterfowl were sufficiently adaptable in habitat and food selection that they could shift to different areas, wetland types, or foods. We now know that some of these assumptions are false and others are under question. Rogers (1979:146) pointed out the importance of understanding annual mortality and the relationship between populations and food resources. These factors have important implications during both the breeding and nonbreeding seasons and must be elucidated to improve management of anatids.

Degradation and loss of habitats commonly used by migrating and wintering mallards are other important considerations. Millions of acres of habitats have been modified in the Mississippi River drainage, particularly in the Illinois Valley (Bellrose et al. 1979), the Missouri River Valley (Funk and Robinson 1974), and in the Mississippi Delta (Korte and Fredrickson 1977, Forsythe and Gard 1980, Fredrickson 1980a, 1980b). The relationships among habitat loss and degradation,

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habitat use, and physiological condition of waterfowl must be better understood.

Waterfowl meet postbreeding requirements through adaptations for wintering at specific wetlands and geographical locations. Wintering waterfowl are adapted to long-term winter-wetland conditions, but are influenced proximately by yearly variations. Waterfowl can respond to changes in winter-wetland conditions both within and among years by moving to more favorable habitats and geographical areas (Heitmeyer 1980). Winter-wetland conditions influence mallard physiological condition and pairing, and potentially, breeding as well.

The annual wetland cycle controls the proximate factors that regulate the timing of reproductive phenomenon such as laying and influence the success of each breeding period. The long-term wetland cycles control the ultimate factors that shape the adaptation of the species to dynamic wetland environments. Our goal in this paper is to provide additional evidence that dynamic wetland conditions outside the prairie breeding grounds may influence the reproductive potential of mallard populations and that more research is needed in this critical area.

Data from Oklahoma and throughout the Mississippi Delta indicate that southern wetlands are dynamic, having four- to fivefold changes in size and number according to season and year. There is a positive correlation between precipitation and number of basins flooded, hectares of surface water, wetland diversity, and emergent vegetation/open water interspersion during winter (Heitmeyer and Vohs 1981). Based on these data, we formulated the following hypotheses:

H_0: Winter precipitation (through its influence on winter wetland dynamics) does not affect mallard recruitment the following year.

H_A: Winter precipitation (through its influence on winter wetland dynamics) does affect mallard recruitment the following year.

We then developed a theoretical test of these hypotheses.

Methods

Index of Winter Wetland Conditions

Winter precipitation data (annual climatological reports, U.S. Dept. Commerce 1961-1979) were used as an index to winter wetland conditions (Table 1). Precipitation departures from normal (deviations from 1891-1979 monthly precipitation means) were recorded by month for 10 geographical sections comprising the primary wintering area of mallards in the Mississippi Flyway (NE, C, S, SC, and SE Louisiana; SE Missouri; and NE, SC, SE, and EC Arkansas). Mean precipitation departures from normal were then computed for four time periods (Nov.-Mar., Dec.-Mar., Dec.-Feb., Nov.-Feb.) to provide annual wintering ground precipitation indices for the 18-year period 1961-62 to 1979-80. We used precipitation departures from normal rather than gross precipitation amounts during winter because mean precipitation amounts vary by region (e.g., Dec. mean of 3.5 inches in SE Missouri vs. Dec. mean of 5.5 inches in SE Louisiana), and because waterfowl are probably adapted to normal long-term precipitation and wetland conditions rather than to specific amounts of precipitation.

Index of Breeding Ground Wetland Conditions

May and July pond numbers in the Prairie Provinces of Canada (U.S. Fish and Wildlife Service survey data) were used as an index to breeding ground conditions (Crissey 1969) (Table 1). We used only strata 26-40 because they represent the major breeding range of mallards in the Mississippi Flyway.

Mallard Productivity for the Mississippi Flyway

We obtained data on mallard age ratios in the Mississippi Flyway harvest for 1961-62 to 1974-75 from Martin and Carney (1977:22) and for 1975-76 to 1979-80 from Sorensen et al. (1980). Despite the problem of using age ratios as indicators of recruitment, these age ratio data were the best readily available indicator of long-term trends for use in our analysis. These data (Table 1) were not adjusted for juvenile vulnerability because uncorrected age ratios seem to be better indices of year to year changes in productivity (Bellrose et al. 1961:454).

Analyses

Simple linear and multiple regression analyses programs in the Statistical Analysis System (Barr et al. 1972) were used to determine relationships between age ratios of mallards in the Mississippi Flyway harvest and the previous winter wetland index (mean precipitation departures from normal), May pond numbers, and July pond numbers. The fitted regression equation was of the form:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + e$$

Table 1. Indices of wetland conditions on wintering (precipitation departure from normal) and breeding grounds (May and July ponds) and mallard age ratios for the Mississippi Flyway from 1961 to 1979.

Winter	Winter (Nov.-Feb.) precipitation departure from normal (in)	May ponds (millions)	July ponds (millions)	Mallard imm/adult ratio in the Miss. Flyway harvest	Breeding year
1961–62	6.23 (15.82 cm)	2.2754	0.7382	1.46	1962
1962–63	−8.08 (−20.52 cm)	2.4755	1.8132	1.35	1963
1963–64	−2.57 (−6.53 cm)	2.7430	1.3083	1.17	1964
1964–65	−0.37 (−0.94 cm)	3.5355	2.2310	1.62	1965
1965–66	2.65 (6.73 cm)	3.7237	1.9792	1.49	1966
1966–67	−6.06 (−15.39 cm)	3.7822	1.4984	1.47	1967
1967–68	−1.83 (−4.65 cm)	1.6357	0.8029	1.10	1968
1968–69	1.41 (3.58 cm)	2.9631	1.6586	1.81	1969
1969–70	−4.24 (−10.77 cm)	4.3890	2.6133	1.19	1970
1970–71	−6.23 (−15.82 cm)	3.8649	2.0168	0.99	1971
1971–72	0.06 (0.15 cm)	3.4351	1.3125	0.96	1972
1972–73	3.84 (9.75 cm)	1.8887	1.7355	1.32	1973
1973–74	6.69 (16.99 cm)	5.6013	2.7355	1.92	1974
1974–75	1.72 (4.37 cm)	4.5865	2.4100	1.36	1975
1975–76	−4.35 (−11.04 cm)	3.8335	2.1524	1.26	1976
1976–77	−3.55 (−9.02 cm)	2.0223	1.3912	0.86	1977
1977–78	1.89 (4.80 cm)	3.4961	1.5203	1.15	1978
1978–79	8.32 (21.13 cm)	4.3193	1.8030	1.43	1979

where Y = age ratio of mallards in the harvest,
X_1 = winter wetland index,
X_2 = May pond numbers,
X_3 = July pond numbers,
e = error term.

Regression analyses were repeated using winter wetland indices for each of the four winter time periods. We also performed a separate analysis using only the last 10 years of data (1969-70 to 1979-80). In all analyses, the independent variable X_1 was computed in three ways: (1) the average of the 10 geographical wintering areas in Louisiana, Arkansas, and Missouri, (2) the average of the five wintering areas in Louisiana, and (3) the average of the four wintering areas in Arkansas.

The notations "P" and "OSL" are used within the text and tables to denote the observed significance levels of individual regression analyses. We used partial F-test significance levels to compare the relative importance of independent variables for predicting age ratios of mallards in multiple regression equations (Draper and Smith 1966).

Results

Winter precipitation departures from normal for the months Dec.-Feb. ($P=0.1142$), Nov.-Mar. ($P=0.400$), and Dec.-Mar. ($P=0.4381$) were not significantly correlated with mallard age ratios in the following year's harvest during 1961-62 to 1979-80. However, precipitation departures from normal for the months Nov.-Feb. were positively correlated ($P=0.0471$) with mallard age ratios (Table 2) suggesting that winter-wetland conditions (via precipitation) do affect mallard age ratios the following breeding season. The Nov.-Feb. time period corresponds closely with the arrival and departure dates of mallards wintering within the Mississippi Delta.

Winter-wetland indices (WINT) during the last 10 years were also significantly correlated ($P=0.0230$) with mallard age ratios (MLAGE) in the following year's harvest (Table 3). The greater significance level and increased slope of the regression line indicated that changes in winter-wetland indices during 1969-70 to 1979-80 suggested a greater influence on mallard age ratios than when all 18 years were considered.

In contrast to WINT, May pond numbers (M_POND) and July pond numbers (J_POND) were not correlated with MLAGE during 1961-62 to 1979-80 (Table 2). The multiple regression using the combination of M_POND and J_POND was not significantly related ($P=0.2451$) to MLAGE. However, the combination of WINT and M_POND was positively related to MLAGE and explained more of the variation ($R^2=0.319$) than WINT alone ($R^2=0.224$). The effect of WINT (partial F-test OSL, $P=0.0814$) was more important than M_POND ($P=0.1706$) in this regression. The combination of WINT and J_POND was more related to MLAGE and explained more of the variation ($R^2=0.367$) in MLAGE than the combination of WINT and M_POND. The combination of WINT, M_POND, and J_POND did not explain any more of the variation in MLAGE than the combination of WINT and J_POND. WINT was the only significant independent variable in this regression; the effect of M_POND was minimal ($P=0.9765$).

When only the last 10 years of data were used, M_POND and J_POND were significantly correlated ($P=0.0369$ and $P=0.0290$ respectively) with MLAGE (Table 3). Neither M_POND nor J_POND explained as much of the variation in

Table 2. Results of simple linear and multiple regression analyses of the mallard imm/ad ratio (MLAGE) in the Mississippi Flyway harvest with the winter precipitation departures from normal (WINT), May pond numbers (M_POND), and July pond numbers (J_POND) from 1961–62 to 1979–80 (standard error of beta values in parentheses under the predicted equation).

Partial *F*-test OSL	Predicted equation	Equation OSL	R^2
WINT = 0.0471	MLAGE = 1.33 + 0.028(WINT) (0.06) (0.013)	0.0471	0.224
M_POND = 0.1001	MLAGE = 0.96 + 0.108 (M_POND) (0.22) (0.062)	0.1001	0.160
J_POND = 0.1224	MLAGE = 1.00 + 0.191(J_POND) (0.22) (0.117)	0.1224	0.143
M_POND = 0.4869 J_POND = 0.6665	MLAGE = 0.94 + 0.072(M_POND) + 0.084(J_POND) (0.23) (0.102) (0.191)	0.2451	0.171
WINT = 0.0814 M_POND = 0.1706	MLAGE = 1.05 + 0.024(WINT) + 0.084(M_POND) (0.21) (0.013) (0.059)	0.0553	0.319
WINT = 0.0357 J_POND = 0.0856	MLAGE = 1.00 + 0.028(WINT) + 0.191(J_POND) (0.19) (0.012) (0.104)	0.0316	0.367
WINT = 0.0558 M_POND = 0.9765 J_POND = 0.3165	MLAGE = 1.00 + 0.028(WINT) + 0.003(M_POND) + 0.187(J_POND) (0.21) (0.013) (0.098) (0.180)	0.0843	0.367

Table 3. Results of simple linear and multiple regression analyses of the mallard imm/ad ratio (MLAGE) in the Mississippi Flyway harvest with the winter precipitation departures from normal (WINT), May pond numbers (M_POND), and July pond numbers (J_POND) from 1969–70 to 1979–80 (standard error of beta values in parentheses under the predicted equation).

Partial *F*-test OSL	Predicted equation	Equation OSL	R^2
WINT = 0.0230	MLAGE = 1.23 + 0.043(WINT) (0.07) (0.015)	0.0230	0.496
M_POND = 0.0369	MLAGE = 0.58 + 0.176(M_POND) (0.27) (0.070)	0.0369	0.439
J_POND = 0.0290	MLAGE = 0.44 + 0.407(J_POND) (0.31) + (0.153)	0.0290	0.469
M_POND = 0.4325 J_POND = 0.3238	MLAGE = 0.41 + 0.090(M_POND) + 0.255(J_POND) (0.32) (0.108) (0.240)	0.0782	0.516
WINT = 0.0246 M_POND = 0.0372	MLAGE = 0.72 + 0.034(WINT) + 0.136(M_POND) (0.20) (0.012) (0.053)	0.0094	0.740
WINT = 0.0004 J_POND = 0.0005	MLAGE = 0.46 + 0.041(WINT) + 0.388(J_POND) (0.13) (0.006) (0.063)	0.0004	0.921
WINT = 0.0014 M_POND = 0.8793 J_POND = 0.0097	MLAGE = 0.47 + 0.041(WINT) − 0.008(M_POND) + 0.401(J_POND) (0.14) (0.007) (0.050) (0.107)	0.0017	0.922

MLAGE as WINT. The combination of M_POND and J_POND was less related to MLAGE than when M_POND and J_POND were analyzed individually, and neither variable was significant. The combination of WINT and M_POND was significantly related to MLAGE and explained 74 percent of the variation; WINT was more important than M_POND. The combination of WINT and J_POND was highly related to MLAGE ($P=0.0004$) and explained 92.1 percent of the variation. The R^2 value (0.921) was almost equal to the sum of the individual WINT ($R^2=0.496$) and J_POND ($R^2=0.469$) regressions, suggesting that J_POND and WINT explained different portions of the variability of MLAGE. The combination of WINT, M_POND, and J_POND did not explain any more of the variation in MLAGE than the combination of WINT and J_POND; WINT was more important than J_POND.

We divided the Nov.-Feb. winter precipitation data into early winter (Nov.-Dec.) and late winter (Jan.-Feb.) to determine if portions of the winter period differentially influenced mallard age ratios the following year. Late-winter wetland indices (LWINT) were correlated with mallard age ratios, but early-winter wetland indices (EWINT) were not (Table 4). Thus, late-winter wetland indices influenced mallard age ratios more than early-winter indices, but neither EWINT ($R^2=0.106$) nor LWINT ($R^2=0.192$) explained as much of the variation in MLAGE as the total winter period ($R^2=0.224$) (Table 2).

When only the last 10 years of data were used, both EWINT and LWINT were significantly correlated with MLAGE (Table 5). Again, neither EWINT nor LWINT explained as much of the variation in MLAGE as the total winter period (Table 3). The combination of EWINT, M_POND, and J_POND explained 84.8 percent of the variation in MLAGE, but only EWINT was significant. The combination of LWINT, M_POND, and J_POND explained 89.4 percent of the variation in MLAGE. LWINT and J_POND were significant, but M_POND was not. When EWINT, LWINT, M_POND, and J_POND were all entered as independent variables, 92.4 percent of the variation in MLAGE was explained; however, only LWINT and J_POND were significant.

Mean precipitation departures from normal for Arkansas during 1961-62 to 1979-80 (ARK18) and 1969-70 to 1979-80 (ARK10) and for Louisiana during 1961-62 to 1979-80 (LA18) and 1969-70 to 1979-80 (LA10) were regressed against MLAGE to determine if geographical wintering areas differentially influenced mallard age ratios (Table 6). Arkansas wetland indices during all 18 years and during the last 10 years were more related to MLAGE and explained more of the variation in MLAGE than Louisiana wetland indices. Both Arkansas and Louisiana winter wetland indices explained more of the variation in MLAGE than the combined wintering grounds (WINT) (Tables 2, 3). ARK18, ARK10, LA18, and LA10 were each combined with M_POND and J_POND in multiple regressions. None explained as much of the variation in MLAGE as the combination of WINT, M_POND, and J_POND (Tables 2, 3). These data suggest that although specific winter areas (especially in Arkansas) are very important, the diverse, scattered wetlands throughout the Mississippi Delta ultimately affect subsequent mallard age ratios to a greater extent than specific areas.

In conclusion, we reject the null hypothesis and conclude that winter precipitation (through its influence on winter wetland dynamics) does affect mallard age ratios the following year. Breeding ground wetland indices also affected recruit-

Table 4. Results of simple linear and multiple regression analyses of the mallard imm/ad ratio (MLAGE) in the Mississippi Flyway harvest with the early winter (EWINT) and late winter (LWINT) precipitation departures from normal, May pond numbers (M_POND), and July pond numbers (J_POND) from 1961–62 to 1979–80 (standard error of beta values in parentheses under the predicted equation).

Partial *F*-test OSL	Predicted equation	Equation OSL	R^2
EWINT = 0.1874	MLAGE = 1.31 + 0.032(EWINT)	0.1874	0.106
	(0.07) (0.023)		
LWINT = 0.0687	MLAGE = 1.37 + 0.042(LWINT)	0.0687	0.192
	(0.64) (0.021)		
EWINT = 0.1122	MLAGE = 0.87 + 0.038(EWINT) + 0.047(M_POND) + 0.154(J_POND)	0.1443	0.311
M_POND = 0.6312	(0.22) (0.022) (0.097) (0.186)		
J_POND = 0.4201			
LWINT = 0.1501	MLAGE = 1.07 + 0.036(LWINT) + 0.008(M_POND) + 0.147(J_POND)	0.1775	0.288
M_POND = 0.9412	(0.24) (0.024) (0.106) (0.189)		
J_POND = 0.4488			
EWINT = 0.2312		0.1758	0.365
LWINT = 0.3135			
M_POND = 0.9546	MLAGE = 0.98 + 0.030(EWINT) + 0.026(LWINT) + 0.006(M_POND) + 0.186(J_POND)		
J_POND = 0.3393	(0.25) (0.024) (0.025) (0.104) (0.188)		

Table 5. Results of simple linear and multiple regression analyses of the mallard imm/ad ratio (MLAGE) in the Mississippi Flyway harvest with the early winter EWINT) and late winter (LWINT) precipitation departures from normal, May pond numbers (M__POND), and July pond numbers (J__POND) from 1969–70 to 1979–80 (standard error of beta values in parentheses under the predicted equation).

Partial *F*-test OSL	Predicted equation	Equation OSL	R^2
EWINT = 0.0520	MLAGE = 1.16 (0.08) + 0.074(EWINT) (0.032)	0.0520	0.394
LWINT = 0.0496	MLAGE = 1.29 (0.08) + 0.064(LWINT) (0.028)	0.0496	0.400
EWINT = 0.0110 M__POND = 0.2052 J__POND = 0.1779	MLAGE = 0.38 (0.19) + 0.068(EWINT) (0.019) + 0.092(M__POND) (0.065) + 0.223(J__POND) (0.139)	0.0081	0.848
LWINT = 0.0036 M__POND = 0.2222 J__POND = 0.0069	MLAGE = 0.53 (0.16) + 0.077(LWINT) (0.017) − 0.091(M__POND) (0.067) + 0.560(J__POND) (0.056)	0.0033	0.894
EWINT = 0.2193 LWINT = 0.0758 M__POND = 0.6844 J__POND = 0.0317	MLAGE = 0.48 (0.16) + 0.031(EWINT) (0.022) + 0.052(LWINT) (0.023) − 0.032(M__POND) (0.075) + 0.449(J__POND) (0.151)	0.0067	0.924

Table 6. Results of simple linear and multiple regression analyses of the mallard imm/ad ratio (MLAGE) in the Mississippi Flyway harvest with the winter precipitation departures for Arkansas during 1961–62 to 1979–80 (ARK18) and during 1969–70 to 1979–80 (ARK10), for Louisiana during 1961–62 to 1979–80 (LA18) and during 1969–70 to 1979–80 (LA10), May pond numbers (M_POND), and July pond numbers (J_POND) (standard error of beta values in parentheses under the predicted equation).

Partial *F*-test OSL	Predicted equation	Equation OSL	R^2
ARK18 = 0.0398	MLAGE = 1.35 + 0.023(ARK18)	0.0398	0.238
	(0.06) (0.010)		
LA18 = 0.0496	MLAGE = 1.35 + 0.027(LA18)	0.0496	0.220
	(0.06) (0.012)		
ARK10 = 0.0033	MLAGE = 1.25 + 0.044(ARK10)	0.0033	0.681
	(0.05) (0.010)		
LA10 = 0.0110	MLAGE = 1.24 + 0.047(LA10)	0.0110	0.575
	(0.06) (0.014)		
ARK18 = 0.0662	MLAGE = 1.03 + 0.021(ARK18) + 0.028(M_POND) + 0.128(J_POND)	0.0969	0.353
M_POND = 0.7724	(0.22) (0.101) (0.095) (0.177)		
J_POND = 0.4795			
LA18 = 0.635	MLAGE = 1.00 + 0.026(LA18) + 0.150(M_POND) + 0.024(J_POND)	0.0939	0.357
M_POND = 0.4152	(0.21) (0.013) (0.178) (0.096)		
J_POND = 0.8034			
ARK10 = 0.0080	MLAGE = 0.71 + 0.034(ARK10) + 0.055(M_POND) + 0.171(J_POND)	0.0063	0.862
M_POND = 0.4122	(0.20) (0.009) (0.062) (0.140)		
J_POND = 0.2681			
LA10 = 0.0040	MLAGE = 0.56 + 0.039(LA10) + 0.248(M_POND) + 0.051(J_POND)	0.0037	0.889
M_POND = 0.0930	(0.17) (0.009) (0.248) (0.051)		
J_POND = 0.3993			

ment; however, winter wetland indices explained more of the variation in mallard age ratios than breeding ground wetland indices. Late winter wetland indices seemed more important than early winter wetland indices, and wetlands in Arkansas seemed more important than wetlands in Louisiana in affecting subsequent mallard age ratios. However, the entire wintering period (Nov.-Feb.) and total wintering range (Missouri, Arkansas, Louisiana) were ultimately more important than specific times and areas.

Discussion

Based on our analyses, wintering habitats within the United States appear to have an important function in maintaining the international waterfowl resource. The interrelationships between winter wetland conditions and mallard age ratios have far reaching implications for management of mallards and possibly other North American anatids as well.

Recent bioenergetic evidence supports our view that favorable mallard age ratios are dependent on the abundance and quality of winter wetlands and July ponds. Early nesting mallards arrive on breeding grounds with about half the protein and all of the lipids necessary to lay a clutch of eggs (Krapu 1981). The first clutch is normally larger (Batt 1979, Krapu and Doty 1979) and nest success is usually higher early than late in the season (Dzubin and Gollop 1972:124). Endogenous reserves provide a majority of the requirements necessary for the initial clutch; hence, May ponds apparently play a lesser role in the first nesting attempt than southern wetlands (Krapu 1981). Breeding habitat conditions are especially important for renesting and for brood survival and explain the value of the July pond index in assessing mallard recruitment. This combination of factors may explain why the importance of May ponds is overshadowed by winter wetlands and July ponds in our analysis.

The increased importance of winter wetlands (Tables 3, 5) in the past 10 years may reflect recent habitat modifications. Wetland loss and degradation is a constant process but wintering habitats, especially those in the Mississippi Delta, are disappearing at an alarming rate (Forsythe and Gard 1980). We estimate that 1.3 million acres (0.52 million ha) of Delta wetlands were lost between 1970 and 1980. Only about 22 percent of the original forested habitat within the Delta remains in forests today (MacDonald et al. 1979). In contrast, 59 percent of the wetlands near Redvers, Saskatchewan and 62 percent of the wetlands near Lousana, Alberta were classed as undisturbed in 1976 (Trauger and Stoudt 1978:197). Possibly the loss of Mississippi Delta wetlands has forced mallards to concentrate on modified habitats and on fewer areas with natural wetlands where survival, behavior, and physiology are affected to such an extent that subsequent recruitment has declined as well. The apparent importance of winter wetlands in recent years could also be related to the gradual perfection in sampling design for obtaining age ratio data and in the reliability of techniques for aging mallards from 1962 to present. Such changes necessitate caution when interpreting our results.

The increasing importance of wetlands in late winter over early winter fits with several known physiological responses of birds. Increasing daylight after the winter solstice triggers hormonal mechanisms that eventually result in egg laying (Murton and Westwood 1977). If behavioral changes and physiological conditions are modified soon after changes in day length, then specific requirements for breeding might be expected as these changes occur. These requirements would be present in late winter and may explain why our analyses suggest that reproduction is influenced by wetland conditions outside the breeding grounds and that late winter is an especially important period.

The wetlands in eastern Arkansas are well known for their importance to mallards. As many as 3 million mallards regularly winter within the Mississippi Flyway and about one third of these normally appear in Arkansas (Bellrose 1978). The importance of winter wetlands in eastern Arkansas, including such famous areas as the Cache River and White River, suggests that the condition of these wetlands may be critical for mallard recruitment.

Our approach of using winter wetlands to understand mallard recruitment may have useful predictive capabilities for estimating the fall flight and in turn may provide new information for setting hunting regulations. Precipitation data are readily available from the National Climatic Center; and inclusion of winter precipitation data would add little to the cost or time required for the analysis. This study and the work of many waterfowl experts suggest that mallards respond to dynamic wetland cycles during all seasons and at all latitudes. We must recognize that southern wetlands used during winter are not static environments, but have annual and long-term cycles that make them as dynamic as the prairie pothole region (Heitmeyer and Vohs 1981). Our analyses relate to the more southern habitats used by mallards in winter but wetlands between wintering and breeding areas may be especially important to early nesting birds that must arrive with the

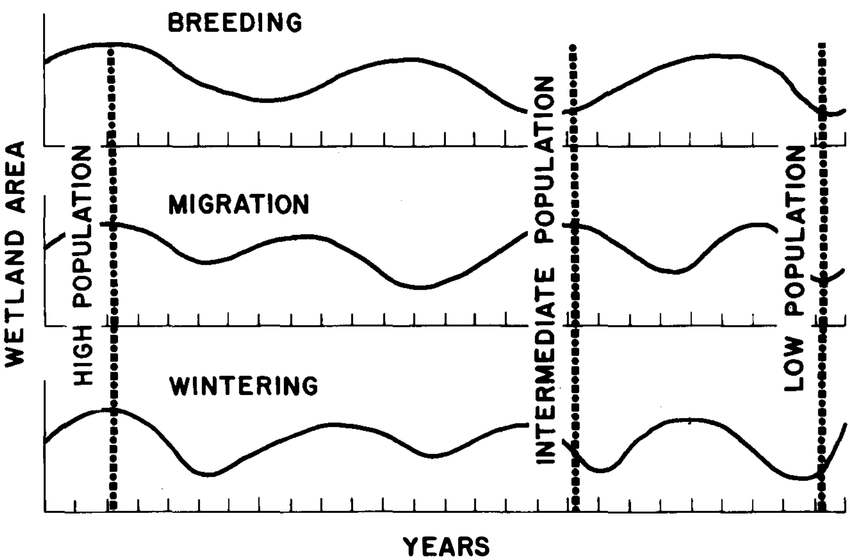

Figure 1. Theoretical long term cyclic fluctuations on breeding, migration, and wintering wetland habitats. Relative size of predicted mallard population is indicated in relation to wetland cycles by vertical bars.

endogenous proteins and lipids required for egg laying. Wetlands used for breeding, migration, and wintering all have cyclic phenomenon and optimal water conditions to assure a readily available source of food resources (Figure 1). Peak mallard populations would be expected in those years when optimum conditions occur on each of these different habitats (Table 1, Figure 1). Likewise, intermediate or low populations might occur when one or more of these habitats provide less than optimum conditions.

The recommendations of previous authors to enhance our understanding of waterfowl populations should be restated (Anderson and Burnham 1976, Rogers 1979). The roles played by food supplies and availability in regulating waterfowl population size, distribution, and health must be elucidated. We must delineate the limiting variables that control mallard populations and establish when they occur. This information is essential for effective management and acquisition in the face of continued habitat loss and degradation.

Acknowledgements

We are indebted to W. D. Warde for his statistical advice. R. A. Black and K. Reinecke provided helpful advice with the preliminary results. S. L. Rhoades provided data on May and July pond numbers. T. S. Baskett, R. D. Drobney, D. D. Humburg, G. F. Krause, M. W. Sayre, S. L. Sheriff, and P. A. Vohs, Jr. kindly reviewed the manuscript. This study was supported in part by Oklahoma Pittman-Robertson Project W-128-R-3 and by Oklahoma Cooperative Wildlife Research Unit, U.S. Fish and Wildlife Service, Oklahoma Department of Wildlife Conservation, Wildlife Management Institute, and Oklahoma State University cooperating. Contribution from Gaylord Memorial Laboratory (School of Forestry, Fisheries, and Wildlife, University of Missouri-Columbia and Missouri Department of Conservation cooperating) and Missouri Agricultural Experiment Station, Project 183, Journal Series No. 8781.

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A Theoretical Approach to Problems in Waterfowl Management

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Introduction

Waterfowl research has traditionally been the domain of the practical ecologist. Investigations reflect a preoccupation with the importance of proximate factors that affect the distribution and abundance of waterfowl such as weather, vegetation, food resources, predators, and man's activities. The depth of this knowledge is considerable (Bellrose and Low 1978), and perhaps no greater quantity of life-history facts has been assembled for any other group of birds. On the other hand, theoretically-oriented ecologists search for generalizations which can be constructed through observations of repeated patterns in nature. Broad applicability and predictive capability are more important than cataloguing facts. Evolutionary ecologists look at life-histories and attempt to determine how evolution has molded organisms to "fit" environments (McKinney 1973). These two research approaches are not mutually exclusive but should be used concurrently to provide basic biological knowledge needed to manage waterfowl. The pressing needs for answers to practical questions will always be present. However, immediate needs should not curtail researchers from looking beyond for repeated patterns, or conducting studies which would attempt to test predictions from theory. We currently lack an overall theoretical framework for interpreting studies and predicting outcomes of management options or directing future research. I don't expect this paper to fill this void, but hope to show that theoretical concepts offer potential as tools in applied research. Similar attempts to bring theory to wildlife management in this forum are available (Nudds 1979, Patterson 1979).

I have used concepts currently investigated by evolutionary ecologists in an effort to examine patterns of reproductive output and changes in population size of prairie-nesting ducks. A model is presented which is conceptually straightforward and therefore runs the risk of over-simplifying complex interrelated phenomena; however, if simple models suffice, there is no need for more elaborate ones (Stearns 1976).

The Role of Natural Selection

Darwin's theory of natural selection is the single unifying concept of the biological sciences, but there has been a great deal of controversy over the level of organization at which it operates. Some (Wynne-Edwards 1962) maintain that the group is the principal unit of selection, but the more widely held belief is that natural selection operates through the inclusive fitness of individuals (Williams 1966). Selection at either level may be possible, but the question is to determine which has had the more important evolutionary consequences (Maynard-Smith 1976). Both views (either implicitly or explicitly) are frequently invoked to explain the adaptive significance of life history phenomena in waterfowl, so it is important that the confusion surrounding the operational level of natural selection be clarified.

The conditions under which group selection will take place are very stringent (small group size, isolation, re-establishment by few founders, panmictic mating system, etc.), and waterfowl hardly meet them. Thus, it appears that the theoretical approach offering greatest potential for understanding waterfowl life-history strategies is the one based on the assumption that natural selection operates at the individual level. Two important concepts implicit in this theory are that (1) the relative genetic contribution over a lifetime (not annual productivity) determines the reproductive success of an individual, and (2) the interests of an individual are not analogous to those of a population or group. How populations behave is of greater interest to managers than the performance of individuals and it may be difficult to see how this theory can be used to address population problems. Fortunately, selection is often stabilizing, individuals in a population tend to do about (but not exactly) the same things. By sampling a population, we can analyze what the average organism is doing. Population parameters such as productivity, survivorship, and growth only reflect the net outcome of individual actions.

Developing the Theory for Duck Populations

Fretwell (1972) modelled the habitat distribution in birds based on habitat "suitability" (*HS*). Suitability is a measure of "goodness" of the habitat based on the individual fitness of birds occupying it, and is important in evolutionarily shaping habitat selection behavior. The link between suitability, habitat selection, and settling behavior may be the key to understanding the annual distribution and abundance of breeding ducks over a wide range of environmental states. The amount and quality of breeding habitat for prairie ducks is largely determined by the quantity of spring run-off and precipitation (Crissey 1969). For these reasons, *HS* is a fundamental variable in the model (Figure 1). It ranges between a theoretical minimum and maximum.

Reproductive effort (*RE*) is the proportion of resources committed to reproduction by an individual during a breeding season. On a population basis, it may be viewed as the sum of all individuals *RE*s, and will vary depending upon what proportion of the population attempts to breed. Organisms may adjust reproductive effort to the chances of success (Williams 1966), and for birds which have evolved in a variable environment, it seems reasonable to assume that those chances would be greatly influenced by the environmental state. The *RE* curve in Figure 1 has been adjusted to reflect *RE* over the range of *HS* and takes the general form of a sigmoidal growth curve. When habitat conditions are poor, and chances of success are slim, few birds settle in the habitat and a comparatively small *RE* is made. Improved *HS* causes an increase in *RE* until all birds capable of reproducing attempt it. Birds physiologically incapable of reproducing, and density-dependent effects may be expected to depress *RE* at the higher levels. The *RE* concept is perhaps most easily visualized when applied to the female breeding population, since it is the hen which homes to her natal area, decides whether or not to settle in the habitat, and the magnitude of *RE*.

The reproductive success (*RS*) curve follows that of *RE* but is somewhat less since a breeding population is rarely 100 percent successful. *RS* may be best defined as fledged female offspring per breeding hen. *RS* for the population is then

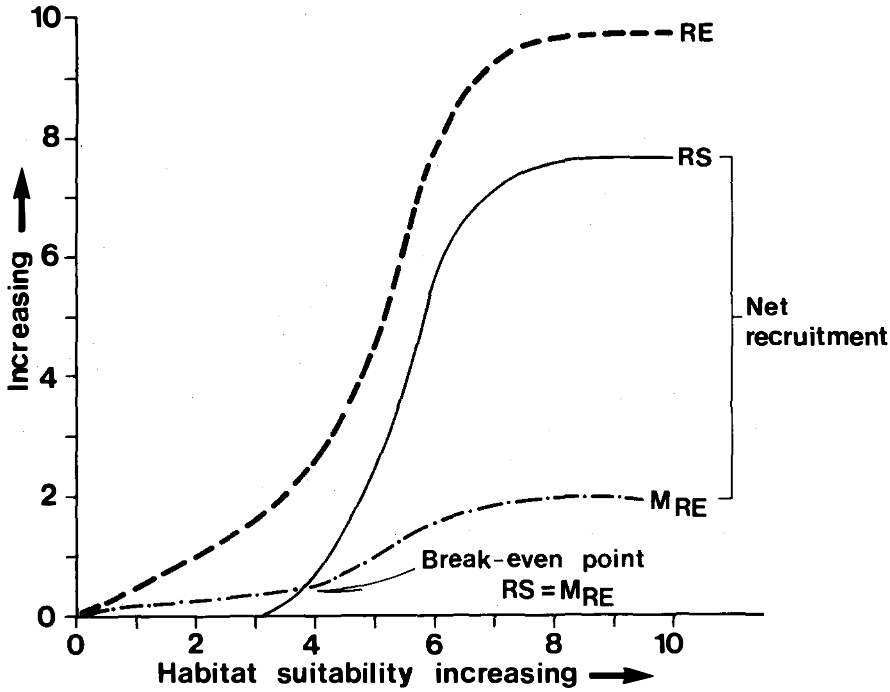


Figure 1. A model demonstrating a theoretical relationship between reproductive effort (*RE*) and success (*RS*) of prairie nesting female ducks, as a function of habitat suitability. M_{RE} (0.20 *RE*) is the cost of reproduction in terms of adult mortality.

the sum of fledged female offspring. The model demonstrates that *RE* and *RS* should increase rapidly with improving *HS*, allowing for substantial population growth during years of good water conditions.

Cost of reproduction (M_{RE}; see Stearns 1976, Cody 1971) is an increase in adult mortality caused by a decision to commit resources to a reproductive effort. There is evidence in ducks that most natural mortality is associated with the breeding season (Stout and Cornwell 1976), and the reproducing bird (Sargeant 1972), but M_{RE} can include mortality sustained after breeding from related physiological stresses. M_{RE} is assumed to be 0.20 *RE*; implicit in this assumption is that M_{RE} is density-independent. The difference between *RS* and M_{RE} represents the net productivity or recruitment in currency of fledged females. At low *HS*, a "break-even" point is reached where $RE = M_{RE}$. Beyond this point any *RE* results in a net loss of females from the population. Natural selection should act against females exhibiting a high *RE* at low levels of *HS*. It is also apparent that if there was no cost associated with *RE*, birds would attempt to breed under any habitat conditions.

Testing the Theory

Theoretical models are useful to managers if they can demonstrate patterns and provide reasonably accurate predictions when empirical data are lacking. To test the model, I selected data gathered by Stoudt (1971) on the mallard *(Anas platyrhnchos)* and canvasback *(Aythya valisneria)* at Redvers, Saskatchewan in a 14 year period from 1952 to 1964. This data base was chosen for several reasons. The mallard is the prominent migratory game species in North America, and annual breeding inventories (Pospahala et al. 1974) are designed with this in mind. Redvers is close to the geographic center of abundance for breeding mallards, and it is likely that the species originated in this type of grassland-parkland ecotone habitat. The work done by Stoudt at Redvers represents one of the most complete studies of the population dynamics of breeding mallards throughout the full range of environmental variability affecting them. Furthermore the study was performed prior to a decade of increased agricultural degradation of habitat and human exploitation of the birds. The study was conducted using standardized field methods (Stoudt 1971).

The canvasback was also included in tests of the model for two reasons. Firstly, perennially low numbers and high desirability as game have made it a controversial management problem. However, the biological reasons for comparing the reproductive strategies of the mallard and canvasback are fundamentally more important. Patterson (1979) compared these species according to r-K theory (MacArthur and Wilson 1967), and concluded that mallards are r-strategists relative to K-selected canvasback because of its ability to react quickly to available breeding habitat, and apparent lack of density-dependent population regulation. r-K theory is based on a dynamic continuum (Nichols et al. 1976), and provides direction in assessing the relative proportions of total resources allocated to reproductive activities among species. Characteristics of r-strategists are a combination of early maturity, short life span, and large reproductive effort; whereas those of K-strategists include delayed maturity, long life, and small reproductive efforts. This has important implications for the form of the *RE-HS* relationship. Based on r-K theory, mallards should have higher *RE* at lower levels of *HS* (i.e., be willing to take more risks), and little depression of *RE* should occur through density-dependent constraints on breeding.

RE is difficult to measure for a population, but can be inferred from variation in the numbers of individuals attempting to breed (Nichols et al. 1976). For ducks this can be estimated by the settling rate (the proportion of the population that establishes themselves on a given unit of habitat). The model predicts that settling rate (and consequently *RE*) is determined by the goodness of the habitat and this accounts for most of the variation in annual productivity.

Habitat suitability was based on the number of Type 3 (Stoudt 1971) ponds present on May 1 and their persistence to July 1. Type 3 ponds were chosen because they probably reflect water conditions better than total pond numbers (which include the more permanent ponds that only dry out during the most severe drought) and ephemeral ponds (which are abundant during excessively wet years). Type 3 ponds persisting to July 1 provide an indication of moisture following spring run-off. *HS* in a given year was the proportion of Type 3 ponds present on May 1 compared to the actual maximum number recorded (191 Type 3 ponds = 100% in 1952), *less* the percentage of these lost by July 1. It is important to note that results based on this index of *HS* do not infer any special biological significance of Type 3 ponds per se.

Settling rate was the breeding pair count in a given year expressed as a proportion of the maximum recorded during the study (mallard, 1952 = 265 pairs; canvasback, 1956 = 32 pairs). I assume that the maximum number of pairs is always available to settle, hence settling rate is a function of habitat suitability. The area did not serve as a drought refuge for displaced birds, so only potential breeders were present (Stoudt 1971).

Annual recruitment to the population depends on the number of breeding pairs and the percentage of these producing young. The production index was the product of the settling rate and the percentage of hens producing a brood in a given year as determined by Stoudt (1971).

Results

The data on mallards and canvasbacks conformed well in each case to predicted patterns in the model (Figure 2). Settling rates and productivity were significant functions of habitat suitability in each species. In 3 of 4 tests, curvilinear functions provided the best fit for the data.

The prediction that mallards would be more likely to expend higher *RE* at lower *HS* than the canvasback was confirmed (Figure 2). Canvasbacks appear more judicious in habitat selection, demonstrating a careful evaluation of the likelihood of success. The difference between *RE* and *RS* curves (Figure 2) reflects the relative efficiency of *RE* in these species. As a K-selected species, canvasbacks should rely more on environmental cues to predict *RS*. It is quite apparent that the canvasback is much more efficient in its commitment of *RE* (Figure 2).

Density-dependent regulators may act to suppress *RE* at high population levels of K-selected species, but have little or no effect on r-selected species. To test this second prediction of the relative position of the two species on the r-K continuum, the number of completed clutches found per breeding pair was regressed on the number of breeding pairs counted for each species (Figure 3). Data for 1952 was incomplete and omitted, as well as years in which no nests were found. The results verified the basic r-K related differences in the reproductive strategies of the two species. Canvasback nesting effort was an inverse linear function of pair density ($r = -0.94, P < 0.01$). Pair density explained 88 percent of the variation in the number of completed clutches per pair. At high densities, clutches per pair fell below 1.0, giving strong evidence of density-dependent regulation of *RE*. The results for mallards were opposite. Nesting effort increased linearly with pair density ($r = 0.88, P < 0.01$), and 78 percent of the variation in the number of clutches per pair was explained by pair density.

Discussion

A complexity of factors affecting breeding population sizes and reproductive success of ducks has hindered a clear understanding of density-dependent population regulation (Dzubin 1969). Dzubin and Gollop (1972) concluded that arguments for density-dependent reproductive success in mallards and the role of spacing behavior as a factor limiting populations remained speculative. Pospahala et al. (1974) suggested that production was a function of population size, but that production rate appeared to be independent of density.

A theoretical approach offered a different perspective on the relationship between carrying capacity, population density, and production. Fretwell's (1972)

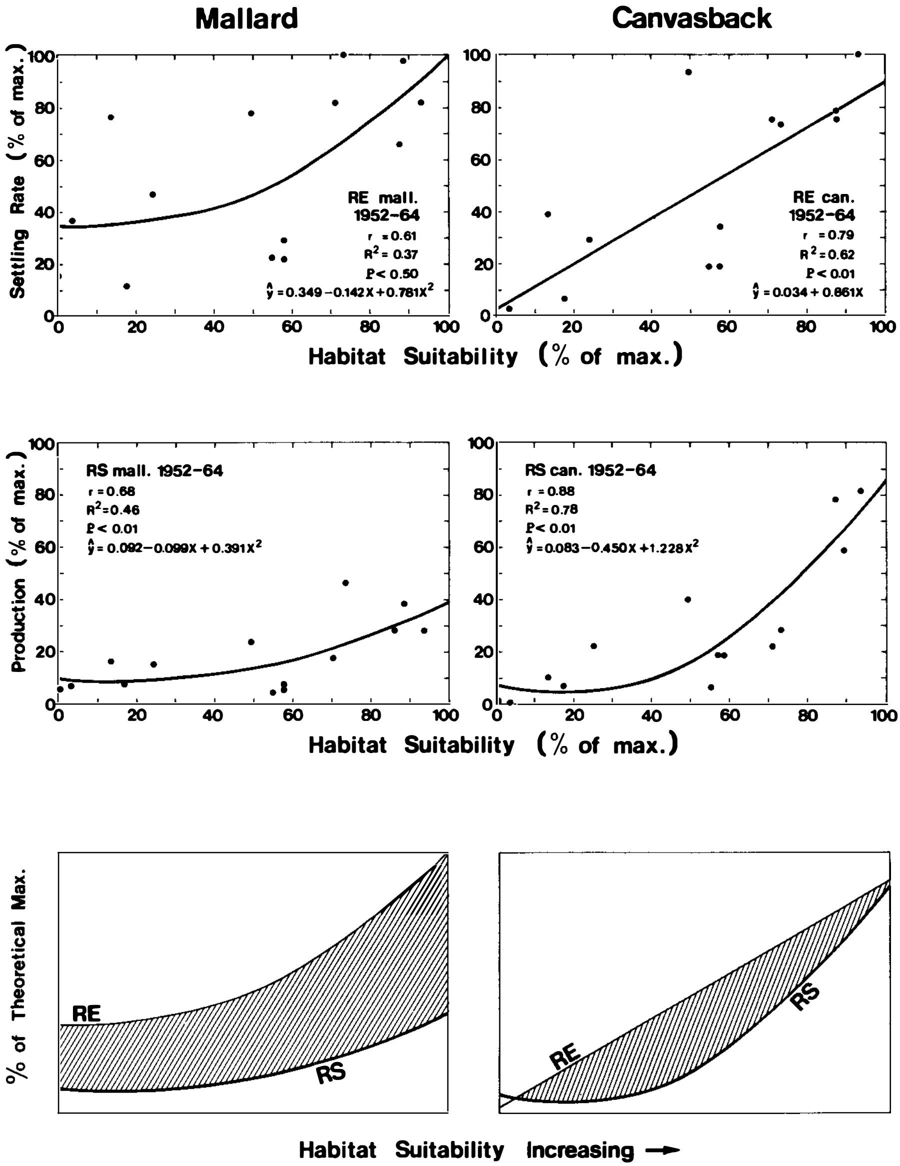
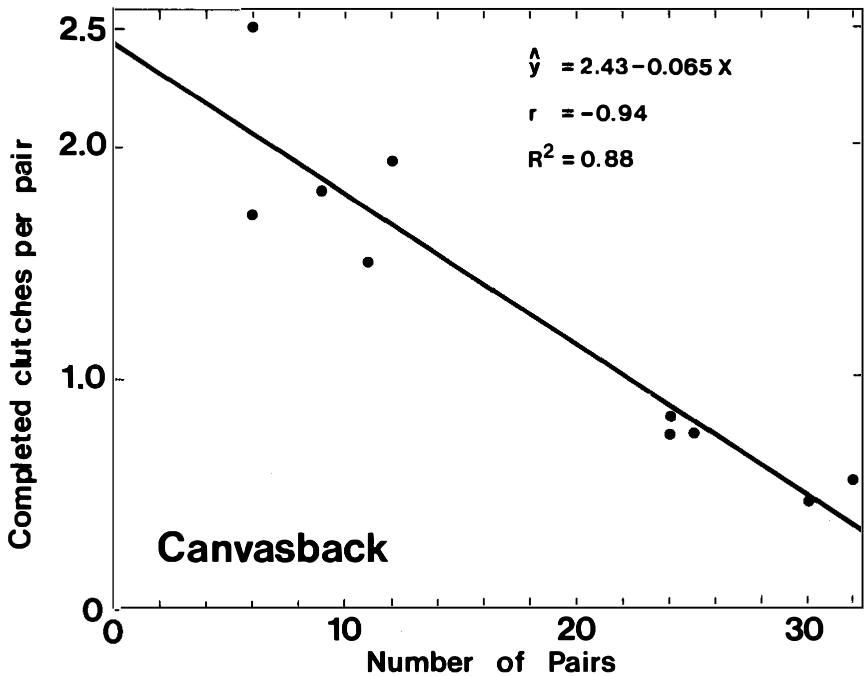


Figure 2. Settling rates, production, and *RS:RE* ratios for prairie nesting mallards and canvasbacks, as a function of habitat suitability, based on data from Stoudt (1971).

theory of habitat distribution predicted that settling rates were a function of fitness in a habitat. Carrying capacity is equivalent to settling rate in the model, since the number of breeders is adjusted to the habitat according to the prospects of successful reproduction. In this sense, the suitability of the habitat is preserved



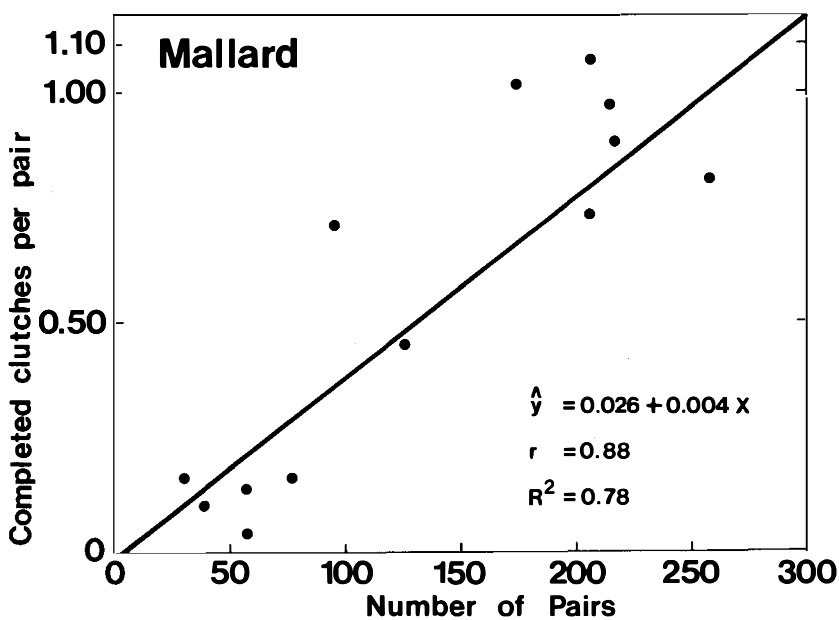


Figure 3. Completed clutches per pair as a function of pair numbers for prairie nesting mallards and canvasbacks, based on data from Stoudt (1971).

(Fretwell 1972), because only the "appropriate" number of birds settle each year. Carrying capacity is a dynamic concept in the prairie environment, synonymous with "goodness" of the habitat.

A large proportion of the variation in settling rates and productivity of mallards and canvasbacks was explained by habitat suitability, and the shape of *RE* and *RS* curves followed predicted patterns in the model. These findings suggest that the model adequately describes the reproductive strategy of these birds, i.e., an evolved relationship between habitat suitability, settling rate, and reproductive success.

Although the two species tested fit the evolutionary framework demonstrated in the model, there are several important differences in the reproductive tactics of these birds. In tests of predictions from r-K theory, the mallard was found to be an "r" strategist relative to the "K"-selected canvasback. These species positions were based primarily on three criteria; (1) the mallard is more "opportunistic", responds quickly to improving habitat, and is willing to accept greater risk of failure in reproduction, (2) there is no apparent density-dependent suppression of *RE* in mallards, as observed in the canvasback, and (3) *RS:RE* ratios in mallards were lower than canvasback. These findings concur with the relative positions of these species on the r-K continuum shown by Patterson (1979).

Williams' (1966) prediction that organisms adapted to living in a variable environment should adjust their reproductive effort relative to the chances of success was supported. However, not all of the variation in *RE* can be explained by *HS* alone. A discussion of *RE* cannot be complete without considering the effects of age and reproductive value (Wilson 1975). Reproductive value (V_x) measures how much a female aged x is worth in terms of the offspring she may contribute to future generations in comparison with other females in the population, and is a function of fecundity and survivorship (Figure 4). Most birds have a fairly constant (Type 11) survival rate following maturity, but seldom do they live beyond the age of active reproduction. V_x increases to age at first breeding, or the turnover point (T), then decreases to the final breeding age. A general prediction from the V_x curve is that *RE* should increase with age (Williams 1966, Gadgil and Bossert 1970).

Age-related productivity has been a focal point of breeding biology studies, and increased reproductive effort and success with age has general support in the waterfowl literature. Older birds have been shown to be more persistent and productive in their breeding attempts (Stotts and Davis 1960, Grice and Rogers 1965, Mihelsons et al. 1970, Heusmann 1975). The lower reproductive efficiency of first-time breeders is often attributed to lack of nesting experience (Bailey 1979). Figure 2 shows greater disparity for mallards between *RE* and *RS* at high levels of *HS* than in canvasbacks, perhaps resulting from a larger proportion of young breeders as the population size increases during series of good years. The inverse situation occurs in canvasbacks, where efficiency improves at high levels of *HS*. However, increases in the population size of canvasback is accompanied by density-dependent suppression of *RE*. Density-dependent factors may be expected to act more strongly against the younger, less efficient breeders. In canvasbacks, the *RS:RE* ratio attains greater disparity at average levels of *HS*, where most young from preceding years are probably attempting to nest. Mallards show no form of density-dependent regulation, and *RE* becomes more efficient as *HS* declines.

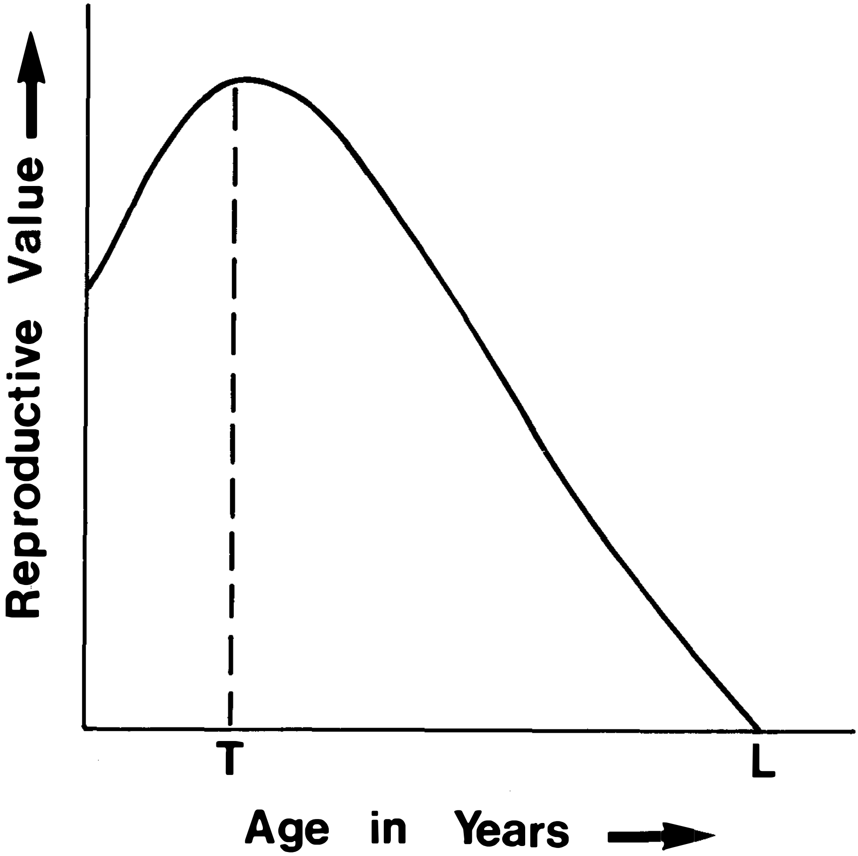


Figure 4. Theoretical interaction between female reproductive value and age for prairie nesting ducks, showing the age at maturity (T) and at last breeding (L).

The effects of V_x on RE become apparent when reproductive performance of r and K species are studied over a prolonged drought. V_x decreases with individual age, perhaps to a point where, for at least a small proportion of the population, it is a more important determinant of RE than HS. Shorter-lived r-selected species do not have comparable options to K-selected birds for postponing breeding, and it may be expected that some breeding by r-selected species would occur during a prolonged drought. Stoudt's (1971) data revealed that a consistently small sample of mallard hens attempted to breed during the most severe drought. I would predict that these were the oldest females with little remaining reproductive value. These hens should thus make a larger than usual RE, since it may be their last opportunity. Evidence supporting this prediction is available in the clutch size data presented by Stoudt (1971: Table 18, p. 32). Average clutch size increased throughout the drought and into the recovery period of low population levels. Clutch size in canvasbacks did not increase over the same period, although sample sizes were smaller. Smith (1971) also reported increased clutch sizes in some ducks during the same drought. I support Nudds' (1978) contention that there is no reason to invoke the group-selectionist arguments proposed by Calverly and Boag (1977) to explain increased values of parameters used to gauge reproductive success, like increased clutch size, during drought.

Management Implications

The model proposes a relationship between ducks and wetland habitats without provision for man's recent intrusions and manipulation of this environment. The question of what effects habitat changes may have on population size or recruitment rates is important to managers. The idea of constructing and testing a model relatively free of man's interference was to provide a basis for evaluating subsequent changes. The fact that agricultural encroachment has recently increased and is continuing is well documented (e.g., Kiel et al. 1972).

The reproductive efficiency curves (Figure 2) indicate how mallards and canvasbacks might be expected to react to habitat loss. Permanent loss of ponds through drainage and manipulation of remaining ones lowers the theoretical maximum *HS*. This situation would cause each species to move left along the curves, depending on the magnitude of habitat loss. Canvasback would be pushed toward the area of greatest deficit between *RE* and *RS*, or lower reproductive efficiency. This situation may be occurring in the Minnedosa area where according to Jerry Serie (pers. comm.), breeding usually occurs in yearling canvasback, but success is limited. On the other hand, mallards are expected to move into an area of increased efficiency. Thus, mallard populations should have improved ability to recover at lower levels of *HS*, but in reality, mallard populations have continued to decline (Patterson 1979). For mallards, evidently, some component of the model, which is based on the abundance and persistence of wetlands as an indicator of *HS*, is missing.

A modification of the model (Figure 5) accommodates the fact that loss of upland nesting cover is believed to be occurring in most prairie regions. The effects of a loss in cover can be manifested in two ways. First, hatching success would be reduced because predators find nests concentrated in remaining cover relatively more efficiently (Hochbaum and Caswell 1978), and a "new" predation regime is set up due to agriculturally-induced changes (Fritzell 1978). Secondly, proportionately greater M_{RE} may be associated with *RE* because of predation on nesting hens (e.g., Johnson and Sargeant 1977). The effects of these factors are to reduce the *RS* curve and increase M_{RE}. There is no a priori reason to believe that the evolved relationship between *RE* and *HS* has changed, consequently mallards will continue to allocate *RE* on the basis of *HS*, but recruitment will be adversely affected. This might result in a new "break-even" point to the right of the old one and *HS* would have to be considerably higher just to maintain the breeding population, even though an absolute loss in wetland habitat is occurring through drainage.

These predictions do not fare well for the prospects of managing an ever increasing demand for ducks in the future. Boyd (1981) has pointed out that over the long term total duck populations have closely tracked the soil moisture regime on the prairies. This finding is in fact coincident with the relationships I have described. However, the results of my theoretical concoctions suggest that for the mallard, it would be very optimistic to expect that population sizes will continue unaffected by degradation of habitat much into the future.

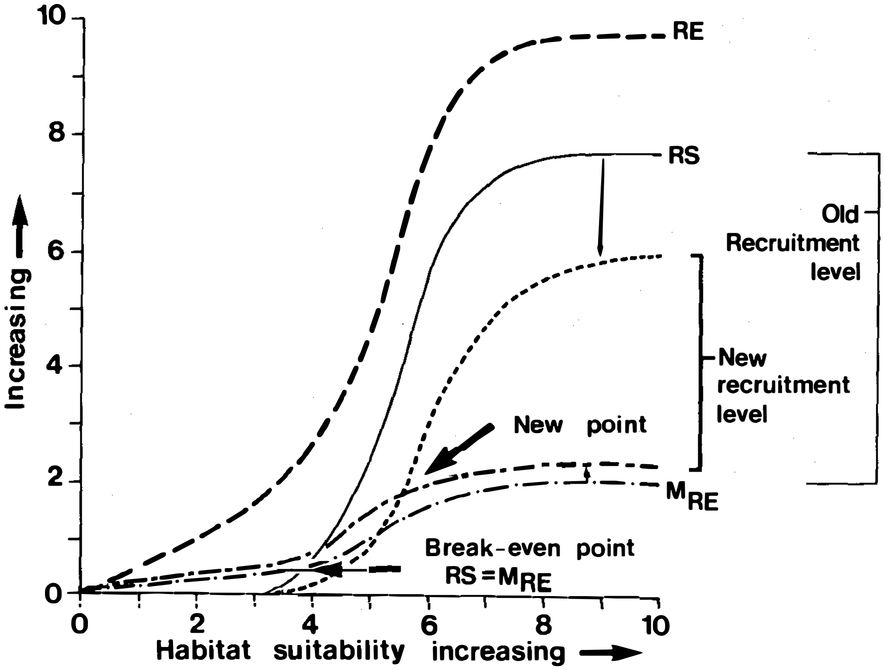


Figure 5. A model illustrating the hypothetical effects of habitat degradation on recruitment levels in prairie nesting ducks. Labels as in Figure 1; see text.

A few additional comments are worth making. First, the model reveals strong ties between *HS*, *RE* and *RS*. Habitat selection has evolved based on cues reflecting the "goodness" of the habitat to returning breeders, and this affects settling behavior. Drought conditions may limit *HS* to a point where the decision not to breed is adaptive. The overflight phenomenon recorded in many species of ducks (Hansen and McKnight 1964, Crissey 1969, Smith 1970, Henny 1973) is predictable as *HS* moves to the left of the break-even point in the model. But more importantly, because of the tie between *RE* and *HS*, there is no a priori reason to believe that prairie ducks displaced to the arctic by drought would attempt to breed. In fact a general prediction from this exercise is that drought-displaced birds simply do not breed.

Second, the model suggests a mechanism for the existence of male biased sex-ratios in mallard populations. Females attempting to breed at low *HS* (some do), will replace themselves less successfully than at high *HS*. A general prediction is the sex-ratios in mallards will change in favor of drakes during years of poor *HS*. Agricultural practices could be aggravating this situation through moving the break-even point to higher levels of *HS*. Predation on nesting hens is probably the single most important factor (Johnson and Sargeant 1977), although other poor conditions for hen survival during drought (alkalinity, botulism, parasitism, etc.) cannot be discounted. Nevertheless, in a conceptual way it is important to realize that male biased sex-ratios could be a by-product of drought and man-made modifications to breeding habitats, rather than resulting from the evolution of male cohorts with an adaptive function (Johnson and Sargeant 1977). It becomes equally unnecessary to invoke differential hunting mortality among sexes as an explanation of disparate sex-ratios in ducks (Olson 1965).

Several fundamental questions remain unanswered. M_{RE} may be an important component in the hypothesis concerning the nature of compensatory mortality (Anderson and Burnham 1976) if it can be shown that predation on nesting hens is density-dependent. Because natural selection is based on the lifetime genetic contribution of individuals there must be a trade-off between *RE* and survivorship. This means that the overflight phenomenon should be viewed as an adaptation enhancing productivity in the long run rather than curtailing it. This situation is analogous to the periodic drying of wetlands that we now accept as necessary to the long-term productivity of the prairie ecosystem. Also, the interaction between *RE,* population density and age structure requires further development.

In conclusion I would like to reiterate that general ecological modelling based on evolutionary theory can be useful in identifying management problems and bringing waterfowl studies together under a common framework. Furthermore, in these times of financial restraint, we must strive to carefully allocate our own resources, which means generating more answers than accumulated facts per invested research dollar (Nudds, pers. comm.). This will require a more efficient scientific approach than has been evident in the past. It also calls for innovation and making productive use of the volumes of data that are already available.

Acknowledgements

Many of these ideas were developed while I was a student at the Delta Waterfowl Research Station. I thank M. G. Anderson and B.D.J. Batt for earlier input and reviews. Encouragement by R. K. Brace and J. H. Patterson of the C.W.S. resulted in production of the paper for this Conference. A. Dzubin and T. D. Nudds reviewed the first draft. I am particularly indebted to T. D. Nudds for several engaging discussions and enthusiastic encouragement in pursuing this work. I am grateful to the Canadian Wildlife Service for the time devoted to the paper, and support in attending this gathering.

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Seabirds: Progress Report on a Neglected Resource

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At the North American Wildlife Conference in 1974, LeRoy Sowl and James Bartonek (1974) presented a paper entitled "Seabirds—Alaska's Most Neglected Resource." This paper could well have included the rest of the continent, as seabirds were nearly everywhere virtually ignored by agencies charged with their protection. Although referring only to Alaska, the authors pointed out that there was no coordinated program for seabird management in North America. Conflicts occurred between the conservation of seabirds and the management of fisheries, marine transportation of petroleum products and other hazardous substances, development of petroleum resources of the outer continental shelf, development of minerals in coastal regions, use of islands for livestock or fur farming, and a variety of other activities in coastal areas that may disturb nesting colonies. Management was generally limited to acquisition of nesting areas. Information about populations and biology of seabirds was fragmentary, particularly in Alaska, and management would be hampered by this lack of basic data.

Because the numerous problems affecting conservation of seabirds described by Sowl and Bartonek are still unresolved, and indeed, have grown more serious, it is appropriate to review progress over the intervening years.

Interest in Seabird Conservation

The widespread interest in seabird conservation by 1975 was made obvious by the broad participation in a symposium entitled "Conservation of marine birds of northern North America" (Bartonek and Nettleship 1979). Presentations addressed topics which ranged from the status of populations and biology of seabirds to conflicts between the conservation of marine birds and use of other resources. While conferees spoke in broad generalities about these topics, lack of data for most species and regions was obvious.

A second and most important indication of interest in seabirds was the formation of the Pacific Seabird Group and the Colonial Waterbird Group. The Pacific Seabird Group was conceived by participants in a symposium about seabirds at a meeting of the Western Association of Naturalists in 1972. Although membership remains small, it probably represents a substantial majority of persons working on the conservation of seabirds in North America. Because its members are broadly representative of agencies, universities, and other organizations in the United States, Canada, and other countries, it is of major importance in facilitating communication and coordination of research techniques and activities.

Along the Gulf of Mexico and Atlantic coasts of the United States, attention was focused mainly on colonially nesting herons and their allies, but did include seabirds. The National Audubon Society sponsored a Colonial Bird Register at

Cornell University, a program that is national in scope (McCrimmon 1978). In 1976, at the North Amrican Wading Bird Conference, the Colonial Waterbird Group was formed. Like the Pacific Seabird Group it facilitates communication and coordination of research techniques and activities.

Broad interest in seabirds could do little to resolve conflicts between their conservation and the use of other resources without substantial support from federal and state agencies. For the period of our report, funding was available primarily from the Bureau of Land Management's (BLM) Environmental Studies Program that was chiefly concerned with the impact of petroleum development on the outer continental shelf. Some agency funding has been available to the Canadian Wildlife Service and the U.S. Fish and Wildlife Service for seabird studies. Peak funding for research on marine birds was provided in 1976 when the Alaskan program alone totaled more than $1.6 million. However, funding decreased rapidly over subsequent years and relatively little work is being supported in 1981. The relatively short term of funding for most projects severely limited the adequacy of information from studies that necessarily required long-term effort. This lack of long-term continuity was particularly limiting to studies that required evaluation of seasonal variation in reproduction, distribution, and food habits. Nevertheless, the research program on marine birds over the last five years constituted one of the largest efforts ever devoted to a single group of nongame species.

A final important feature of research on marine birds, particularly that supported by BLM in Alaska, the Gulf of Mexico and California, is that many studies were part of an interdisciplinary program, and thus benefited in a major way from concurrent work in oceanography, fisheries, and other biological and physical sciences.

Progress in Research

Because of needs of funding agencies, research on seabirds focused primarily on information critical to assess the probable impacts of petroleum development. Studies concentrated on identification and status of nesting colonies, seasonal distribution of birds at sea, reproductive ecology of key species at representative colonies, assessment of food habits and trophic relationships, and occurrence and effects of contaminants.

Cataloging of Colonies

Major progress was made in the identification and evaluation of nesting colonies. This work resulted in publication of an atlas of colonies in Alaska (Sowls et al. 1978) and a catalog of historical nesting colonies of Washington, Oregon and California (Peters et al. 1978, Varoujean 1979). A detailed field study of colonies was completed along California's coast (Sowls et al. 1981). A map identifying colonies and species abundance was completed for British Columbia (circa 1977). Except in certain regions of Alaska, most nesting colonies along the Pacific coast are known.

During this same period since 1974, nesting colonies were identified and evaluated along the Atlantic, Gulf of Mexico and Great Lakes coasts within the U.S. (Portnoy 1977, Buckley and McCaffrey 1978, Chaney et al. 1978, Osborn and

Custes 1978, Erwin 1979, Korschgen 1979, Korschgen and Erwin 1979, Parnell and Soots 1979). Results of recent studies indicate that information available in 1974 was probably even less reliable than believed (Bartonek and Sealy 1979, Manuwal and Campbell 1979, Sekora et al. 1979, Sowl 1979). Much information is still lacking on the status of individual colonies, in particular on seasonal variation and long-term trends in numbers of individual species. In Alaska where more than 1,000 colony areas (many composed of several colonies) with an estimated population of 40 million birds are scattered along 34,000 miles (54,716 km) of coast, gathering of such information for even a few representative areas will require major effort.

Distribution of Birds at Sea

Although seabirds are ubiquitous in marine waters their distribution is patchy and related to the distribution of food resources and major colonies. Species differ in their pattern of distribution but, in general, seabirds are highest in number near shore and at the edge of the continental shelf, somewhat fewer in number over the shelf, and much less abundant over oceanic regions.

Numerous surveys of birds at sea have been conducted from both ships and aircraft in all ocean areas of Alaska (Wiens et al. 1978, Divoky 1979, Forsell and Gould 1980, Hunt et al. 1981). Although data for restricted areas such as the California Bight and waters off Kodiak Island in the Gulf of Alaska are extensive, knowledge of the distribution of birds at sea is inadequate for most of the Pacific coast, as there are large seasonal and geographic gaps in information for nearly all regions.

Nearly the same summary may be made for bird distributions at sea in the Atlantic Ocean and the Gulf of Mexico, albeit, there are far fewer survey data available. In the Atlantic, the Manomet Bird Observatory has conducted surveys of the Georges Bank and Baltimore Canyon areas, and Rowlett (1980) summarized seven years of observations in the Chesapeake Bight area. Surveys sponsored by BLM are being conducted in portions of the Gulf of Mexico by the U.S. Fish and Wildlife Service and Texas A&M University.

Reproductive Ecology

Long-term studies have been conducted on the Channel Islands and on the Farallon Islands off California. Similar studies have been conducted on Destruction, Protection and Smith islands in Washington and on Mandarte, Traingle and other islands in British Columbia. In Alaska, intensive one to two year field studies were conducted at about 20 locations by various agencies and institutions as part of the BLM Environmental Studies Program and continuing programs of the Fish and Wildlife Service. Studies for three years or more were completed only at the Barren and the Semidi islands in the Gulf of Alaska, the Pribilof and Bluff islands in the Bering Sea, and at capes Thompson and Lisburne in the Chukchi Sea. Intensive field work has continued only at colonies in the Barren and Semidi islands, a far from adequate sample of the diverse species and colonies on the Alaskan coast. Along the Atlantic coast, the U.S. Fish and Wildlife Service is conducting long term studies of selected species. These studies currently focus on the relationship of nesting habitat to reproductive success (Erwin, pers. comm.).

Food Habits and Trophic Dynamics

Studies of food habits of seabirds generally coincided with pelagic censuses or with colony studies. Most data were collected during the summer and information for winter periods is generally lacking. Existing data permit several broad generalizations about foraging behavior and diets. Seabirds associate with oceanic features such as upwelling or frontal systems rich in food (Siegel-Causey 1979, Hunt et al. 1980). There is a strong correlation between reproductive performance and food supply (Boersma 1978, Baird 1979, Vermeer 1980). Yet information on food habits remains totally inadequate for many species or for purposes for which more than generalized data are required. For example, while we know that major changes in food supply inhibit reproduction, the effect of small or moderate changes in food supply on reproduction is unknown. Such changes may be critical as a slight reduction in reproductive performance caused by changes in food supply may preclude recovery of populations that have been depleted by direct mortality due to catastrophes.

Effect of Pollutants

Most information about seabirds and pollutants relates primarily to direct mortality associated with oil spills. Although the death of oiled birds receives much attention, meager information is available about the mortality of individual species in relation to the size and distribution of the populations at risk, or the long-term effect of such losses on populations. Less obvious direct effects of oil may occur from decreased hatching success of eggs contaminated by oil (Ohlendorf et al. 1978, Patten and Patten 1978, Ainley et al. 1979, Stickel and Dieter 1979). To provide perspective, Biderman and Drury (1980) note that a significant decline in productivity may occur when as little as one twentieth the amount of oil in a drop from an ordinary household eyedropper is applied to eggs of mallards.

Relatively little has been accomplished in measuring the indirect or long-term effects of pollution on seabirds although organochlorine residues were found in eggs from 19 species of seabirds from Alaska (Ohlendorf et al. 1978, 1980). Boersma (NOAA 1980), working with storm-petrels, has initiated studies of petroleum residues in food brought to nestlings, a potentially important method of monitoring the presence of oil in the marine ecosystem. Although these and other experimental studies should be continued and in some cases expanded, comprehensive long-term studies associated with actual oil spills are needed.

Resolution of Current and Potential Problems

We view the period between 1974 and 1981 with mixed reaction. On the one hand we are able to point at major, even spectacular advances in knowledge of the biology of many species and an increased concern by agencies and the public for seabird conservation. On the other hand, we are most fully aware of the voids in information that still exist, the need for greater coordination of research and management programs, and the need for stable funding.

Protection of Nesting Habitat

While other developments in coastal areas and the introduction of predators or livestock caused destruction of much nesting habitat, such losses have diminished or reversed in recent years. Many island colonies are now protected as refuges or parks. The Alaska National Interest Lands Conservation Act of 1980 placed all unreserved lands on islands in Alaska in the National Wildlife Refuge System, leaving relatively few major colonies in other conservation systems or on Native owned lands. In Alaska, introduced predators devastated populations of burrowing species such as storm-petrels and tufted puffins. Surveys conducted by Bailey and Faust (1978) revealed that introduced foxes did not survive on many small islands and that birds had recolonized some islands. Current research may provide means for removal of foxes from larger islands and eventual restoration of avian populations.

Conflicts with Commercial Fisheries

The entanglement of seabirds in gillnets continues to cause losses that may total thousands of birds annually in the North Pacific and the Bering Sea (DeGange 1978, King et al. 1979). A more serious problem may occur with expansion of fisheries to capelin, sandlance and similar species as such fisheries would threaten vital food supplies of seabirds (Nettleship 1977, MacCall 1979, Straty and Haight 1979). On the other hand, offal and other waste from fishing fleets may increase food available to some species.

Restrictions on gillnet fisheries imposed by treaties, and by authority of the Fishery Management and Conservation Act of 1976, may significantly reduce losses of birds in the Pacific Ocean and Bering Sea. Although we view the likely increase in fisheries on capelin with concern, knowledge of food requirements of seabirds is probably not yet sufficient to demonstrate effects that would influence Fishery Management Councils at the present time.

Petroleum Development

The development of petroleum resources on the outer continental shelf clearly poses a major problem for numerous species of seabirds on both the Atlantic and Pacific coasts. This problem may be most acute in the Atlantic where populations of alcids have continued to decline, although actual mortality there may be dwarfed by that in Alaska where losses of birds from a single spill could conceivably number in the millions.

Other than the identification of critical areas and habitat that should be protected, research has not produced means for prevention of losses from oil nor are such results anticipated. Partial mitigation of such losses, however, may become possible. The future of seabirds may rest largely with agencies regulating development activities and on continued improvement of technology by industry.

Other Development Activities

Developments that increase activity in coastal regions—mining, fishing, petroleum development, urban development, and recreation—may adversely affect populations of seabirds, particularly during the nesting season. Certain activities are clearly deleterious, for example, the trampling of burrows by persons visiting colonies. Other disturbing influences such as low flying aircraft also have been implicated in the loss of eggs or chicks. However, colonies continue to thrive at airports, near boat harbors, and at other areas in which birds are frequently disturbed. This suggests that some species of birds adapt to such activity; that effects of disturbance are still not clearly understood; and in general, that while not a matter of major concern in some areas or for some species, precautions should be taken. We believe threats posed by oil pollution and expanded fisheries to be the major threats confronting seabirds in Alaska. Along the Gulf of Mexico and Atlantic coasts habitat alteration of nesting and feeding areas along with contaminants are also major concerns.

Prospects

Although significant progress on many fronts has been made since the report by Sowl and Bartonek in 1974, the future for seabirds appears bleak. Clearly major contributions have been made to knowledge of populations, biology, and habitats of marine birds. Such information is being given increasing consideration by state and federal agencies in decisions affecting coastal and marine habitats. However, the world's need for energy continues to accelerate the development of petroleum resources on the outer continental shelf; and demand for protein will continue to encourage expansion of fisheries. Because both fisheries and oil pollution tend to adversely affect the same species, the impacts of these industries could be additive. Populations of puffins and murres in the Atlantic are already depleted. In the Pacific, losses of birds may be locally devastating, but the large, widely distributed populations of most species ensure that many colonies may survive relatively unaffected by development activites.

Of all marine creatures, birds are indisputably the most adversly affected by oil pollution (National Academy of Science 1975: p.106). Considering the relatively large losses to populations of marine birds that are likely to occur, the hazards posed by commercial fisheries, the development of hydrocarbon resources of the outer continental shelf and other activities, and the small effort devoted to the development of methods for avoiding or mitigating losses, we conclude, as did Sowl and Bartonek, that seabirds are a neglected resource.

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Status and Management Needs of Migratory Game Birds in the Central American Region

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Each fall millions of migratory game birds leave their breeding grounds in North America and move into wintering areas scattered throughout the countries of Central America. In recent years there has been an increasing need for information on the ecology and management of these birds during their wintering period. While working as a wildlife biologist in Honduras from October 1975 to February 1980, I had the opportunity to participate in the planning and implementation of wildlife projects in that country, and to observe the status of wildlife management throughout the Central American region. This paper focuses on problems related to wildlife management in Central America, with special reference to the needs of some migratory species of the families Columbidae and Anatidae.

The seven most common migratory game birds in the region are the white-winged dove, *Zenaida asiatica,* the mourning dove, *Z. macroura,* and five species of ducks: blue-winged teal, *Anas discors;* pintail, *A. acuta;* shoveler, *A. clypeata;* wigeon, *A. americana;* and lesser scaup, *Aythya affinis* (Land and Trimm 1970, Mendez 1979, Monroe 1968, Ridgely 1976, Russell 1964, Saunders et al. 1950, Slud 1964). These species share wintering habitat with three principal resident species: fulvous whistling duck, *Dendrocygna bicolor;* black-bellied whistling duck, *D. autumnalis;* and muscovy duck, *Cairina moschata.* With the exception of Belize (Russell 1964), each country has a small and scattered resident population of white-winged doves. A resident population of mourning doves has been reported in Panama (Ridgely 1976), Nicaragua (Estrada 1978), and Costa Rica (Slud 1964).

The wintering period for migratory species varies from year to year but normally lasts about 6 months, from mid-October to early April. By far the greatest concentrations of all migratory game species are along the Pacific Coastal Region of Central America, where many bays, lagoons, marshes, and small lakes provide ample habitat. Agricultural production in the area (particularly sorghum and rice) makes winter food readily available for large numbers of doves and ducks. The lowlands of the Caribbean Coast attract many waterfowl but are less favorable for wintering doves because agricultural grain production there is relatively limited.

Smaller numbers of waterfowl spend part of the winter in the interior of this region, particularly at Lake Atitlán in Guatemala, Lake Yojoa in Honduras, lakes Managua and Nicaragua in Nicaragua, and other smaller highland lakes throughout the region. Doves, although initially attracted to the coastal area, move into the interior as grain crops mature and available food and water supplies become diminished along the coast.

Collection of harvest data in Central America has been sporadic and unorganized. Some birds are taken by residents using shotguns, rifles, slingshots, traps, and poisons. The taking of birds by residents can be considered as subsistence hunting by the rural population. The birds constitute an important source of animal protein that often is not available from other sources. My observations indicated that the collection of game birds for sale in markets and restaurants is not common in the region. Sport hunting is more or less limited to the wealthy. Guns and ammunition are expensive and few people can afford them. The average cost of a box of 12-gauge shells in 1979 was about $11. Most birds are taken by nonresident hunters from hunting clubs based in the United States; however, reasonably sound harvest data are available only for mourning and white-winged doves from Honduras and Nicaragua.

In Honduras the hunting season for migratory doves extends from November 1 to March 15. The number of North American hunters in this country increased from just over 200 in the 1974-75 season to nearly 1,100 in 1979-80. During the 6-year period nearly 4,000 hunters harvested an estimated 453,000 doves in southern Honduras (Purdy 1978, 1980).

In Nicaragua the dove hunting season generally extends from October to April. On the basis of harvest data collected during the 1976-77 and 1977-78 seasons, the estimated total kill for the two years was 261,000 doves (Estrada 1978).

As of 1975 the governments of El Salvador and Guatemala banned the introduction of firearms by nonresidents. Before that time, North American hunters traveled annually to these countries for migratory bird hunting, but harvest data were not collected.

Costa Rica planned to allow its first organized nonresident dove hunting season in 1980-81 (E. Lopez, pers. comm.). No data are available on the harvest of game birds in Costa Rica, Panama, or Belize.

Hunting pressure on waterfowl by both residents and nonresidents is light throughout the region, and the total kill is only a small percentage of the wintering birds present. Little information is available on hunting pressure on waterfowl in the area.

Wildlife management is basically a new but developing concept in Central America. It has been only since 1974 that wildlife departments were formed in Honduras, Guatemala, and Costa Rica (Morales et al. 1978). Departments in the other countries are older, but have not progressed significantly. Development and implementation of research and management projects in wildlife have been, and continue to be, restricted by at least six factors: (1) lack of trained personnel to plan and conduct base-line investigations; (2) lack of equipment and financial support for projects; (3) lack of effective wildlife legislation; (4) political unrest and instability of local governments; (5) widespread belief that wildlife is an inexhaustible resource; and (6) lack of coordination in natural resource management at an international level.

Fewer than 25 biologists are currently conducting wildlife research or management in the region, and only a small percentage of these are adequately trained in wildlife management. Most natural resource agencies, and especially wildlife departments, operate with a small budget and little equipment. In 1979 the average wildlife department budget was about $150,000. Most personnel engaged in wildlife management in the region work diligently and enthusiatically despite the inadequacies of equipment and financial support.

National laws and regulations relating to the use and protection of wildlife are inadequate throughout most of the countries. Existing laws are often poorly interpreted or completely unknown to the average citizen. Law enforcement personnel are poorly trained, underpaid, and hampered by lack of transportation and means of communication.

One needs only to examine a daily newspaper to be convinced that the political situation in Central America is far from stable. Changes in governmental leadership usually result in personnel changes down through the ministry and departmental levels. Qualified personnel are replaced and momentum is lost in research and management activities. Projects planned by one administrator are often not regarded as significant by his successor.

There is an underlying feeling throughout Central America that wildlife resources are inexhaustible. Tourist agencies are perhaps the greatest promoters of this idea, and exert continual pressure on wildlife agencies to offer no-limit hunting, without closed seasons. The argument is that migratory birds have always wintered in the area and that they will continue to do so. No-limit hunting is, of course, directed at attracting the greatest possible numbers of nonresident hunters.

Communication between countries and between governmental agencies and other scientific institutions is inadequate or lacking. Instability of governments and institutions within these countries has inhibited effective cooperation in research and management.

Some effort, however, has been directed toward international exchange of information in the region. Perhaps the most important organization now functioning at a regional level in Central America is the Tropical Center for Agricultural Investigation and Training, in Turrialba, Costa Rica. The Watershed and Wild Areas Unit of this Center has been extremely effective during the last 5 years in coordinating regional seminars, meetings, and workshops related to natural resource management. This Unit was responsible for the organization of the First Regional Central American Meeting on Wildlife, held in Nicaragua in 1978.

The International White-winged Dove Council (1976-78) was successful in bringing together the Central American countries with Mexico and the United States in an effort to quantify problems related to the international management of white-winged doves. A questionnaire was developed and has been completed by each Central American country in reference to the status of white-winged and mourning doves in the region. This information is being summarized for publication (R. Tomlinson, pers. comm.). Unfortunately, the Council has not had sufficient funds to support much-needed research related to migratory dove management. Major areas of concern expressed by the Central American wildlife departments include analysis of pesticide related problems, habitat loss, and lack of base-line data.

Locally, some progress has been made in the management of migratory birds. In 1976 the government of Honduras established a hunting season and bag limit for migratory doves, and discontinued issuing permits to nonresidents for waterfowl hunting.

After the 1979 revolution in Nicaragua, the Reconstruction Government formed the Nicaraguan Institute of Natural Resources and Environment. A department of wildlife is included in the Institute. Nonresident hunters have been encouraged to return to that country, and collection of harvest data will be continued (S. Estrada, pers. comm.).

In Costa Rica, hunting regulations have been established for migratory game birds. The first waterfowl refuge (Palo Verde) in Central America has been successfully established in the northwestern section of that country. A regional training facility for wildlife management is being established in Costa Rica through the joint efforts of the Rare Animal Relief Effort, World Wildlife Fund, Nature Conservancy, the U.S. Fish and Wildlife Service, the U.S. National Park Service, and the Agency for International Development (Bertrand 1979).

The future of migratory game birds is dependent on cooperative management at an international level. In Central America, a number of immediate investigational needs are evident: (1) base-line studies on migratory game bird populations; (2) analysis of winter habitat; (3) analysis of agriculturally related problems (habitat alterations, pesticide use, and crop depredations); and (4) analysis of hunting pressure throughout the region.

The density and status of game bird populations have not been studied in detail anywhere in the Central American region. Only sporadic and short-term investigations have produced the little information that is available.

The current status and security of wintering habitat for migratory species must be ascertained. Increasing human population and accelerating demand for agricultural land and timber for fuel and construction are claiming wildlife habitat daily. The population of Central America has been estimated to be about 17 million people, and is increasing at an annual rate of over 3 percent (West and Augelli 1976). All of the major population centers are in the Pacific region. El Salvador, for example, in 1972 had an average density of 185 persons per square kilometer (Daugherty 1972), one of the highest population densities on the mainland of the western hemisphere.

Deforestation, erosion, draining of lagoons and marshes, and pesticide residues are having drastic effects on the wintering grounds and distribution of many migratory species. Along the entire Pacific Coast, from Guatemala to Costa Rica, practically every parcel of land considered suitable for cotton production is being converted to that use. This has led to excessive application of pesticides in some areas. Efforts must be directed toward determining the kinds and quantities of chemicals being used. Individual species of birds should be examined to determine the significance of existing levels of contamination. This information could be used in the formulation of regulations concerning proper application procedures for pesticides.

Problems related to depredation of grain crops by migratory species (especially columbids) should be investigated. Small subsistence farmers throughout the area are particularly affected by crop losses to birds.

Hunting pressure by resident and nonresident hunters must be analyzed. Numbers of hunters, daily take, and methods of hunting are important in evaluating the overall pressure on migratory species in the region.

Conditions affecting migratory game birds in their wintering grounds are of extreme importance to the governments of Mexico, the United States, and Canada. Research on these species should be actively supported and encouraged by governmental agencies in these countries. A coordinated international effort should be initiated in Central America to evaluate existing wintering habitat, standardize techniques for investigating and monitoring pesticide problems, collect base-line data on migratory species necessary for effective management of the resource, and promote exchange of ideas and information. Programs must be encouraged that will enhance public understanding and appreciation of wildlife resources.

Above all, it must be remembered that migratory species are truly an international renewable natural resource and therefore demand cooperative management efforts among all nations sharing in their use.

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A Fair Future for Prairie Ducks; Cloudy Further North

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Let me begin with quotations from two Englishmen who have influenced me. The first was a copious yet distinguished writer of fiction who died in 1975 at the age of 93. In a story published in 1947 he wrote (P. G. Wodehouse, *Full Moon*) of an imaginary American in London:

> He was feeling very low now, low and despondent, and taking all the circumstances into consideration it seemed to him that the best thing to do was to step into the park and take a look at the ducks on the Serpentine. He had often found the spectacle of these agreeable birds act as a sedative in times of mental stress, soothing the soul and bringing new life and courage. And, indeed, there is always something very restful about a duck. Whatever earthquakes and upheavals may be afflicting the general public, it stands aloof from them and just goes on being a duck.

My second set of quotations comes from a former schoolmate fortunately still alive, now at the Institute of Animal Resource Ecology of the University of British Columbia. Neil Gilbert, reviewing a British Ecological Society (B.E.S.) Symposium on *Population Dynamics,* noted that "It marks a considerable advance over similar productions of 20 years ago." On individual papers he notes of one that it demonstrates "just how vagile are wild populations"; of another that it shows "that classical notions of stability and steady state equilibrium have little relevance to the real world of ecology." Twenty years ago I read at another B.E.S. Symposium on population dynamics a paper comparing waterfowl populations, choosing examples of populations that appeared to be in a steady state. I would not do so now. We are indeed working with highly mobile populations that are not in steady states. Gilbert noted that we can only deal with "the baffling complexity" by (1) unrealistic over-simplification or (2) clumsy simulation models.

As a long time practitioner of *unrealistic over-simplification* I have three good reasons for "feeling very low, low and despondent." First, and trivially, the work on which this paper is based has bogged down (temporarily) in "the baffling complexity." Second, some necessary changes in the approach to waterfowl management that we seemed close to achieving in Canada may now be snatched away again.

Third, just this morning I heard bad news. An 18th century Scot, James Watt, is credited with the invention of the steam engine. His latter-day namesake from Wyoming "that agile and mellifluous quodlibertarian"—to borrow again from a dead Englishman—threatened today to stoke up engines of environmental depravity far worse than anything the Scotsman achieved.

Two points in the Secretary's remarks caused me particular concern. First, he dismissed international conservation concerns with a single sentence: "On the international front, we will be careful not to make agreements which are detrimental to State and Federal fish and wildlife programs." So much for joint stewardship of the migratory birds of North America.

Second, in keeping with his expressed personal philosophy, but in defiance of the facts of life, he proclaimed "America's resources were put here for the enjoyment and use of people. . . . " Popular that belief may be, but it is false. There is no reason to accept the view that birds, or any of the other living inhabitants of the world, are "here for the enjoyment and use of people," and it is mischievous to do so. Birds and other animals exist in their own right and for their own enjoyment—if that is the right word. Fortunately, the birds know this and that it takes a duck to make a duck (or two, if you prefer).

But I have been led astray. What I am supposed to be talking about are some investigations of the numbers of dabbling ducks recorded in the aerial sample surveys of northwestern North America which have been made each year since 1955 by the U.S. Fish and Wildlife Service, with a little help from the Canadian Wildlife Service (CWS).

The conceptual and statistical basis of those surveys were recently reviewed by Martin et al. (1979) and my own investigations are being reported in detail elsewhere (Boyd 1981, and in prep.), so that I will spend no more time here in discussing methods and limitations. The May and July surveys were devised to provide up-to-date information on the status of ducks in their principal breeding areas, for use in the annual setting of regulations governing waterfowl hunting in the United States. Their chief interest has been supposed to lie in the year to year variation in the number of ducks and of ponds in the Canadian prairies and in the departure of the current year's values from the long-term averages. Now that we have moved, in both the U.S. and Canada, to a period of 'stabilized' hunting regulations, in which it is intended that changes in the framework will be few, we can concern ourselves, more profitably I believe, with fluctuations over decades rather than from one year to the next. It will not be easy to change our way of looking at events, but it is good that we should have this chance of doing so.

If we look at what has happened to the dabbling duck populations in the surveyed areas, we see that in the Canadian prairies and the Mackenzie Valley the numbers were greater in the first two or three years than they have been since. I have argued elsewhere (Boyd 1981) that the reason for the large numbers on the prairies in the mid-1950s was that conditions were then more favourable for ducks than at any other time in the last fifty years. Lynch et al. (1963) seized on that point as long ago as the 28th North American Wildlife Conference. The earliest years apart, the remarkable feature of these records is that we still have very many dabbling ducks breeding in northwest North America.

For more than fifty years analysts and prophets of all sorts have been recording and bemoaning the destruction of wetlands, both in the prairie breeding areas and in the places where ducks spend the winter or live while on migration. Wetland destruction, and its acceleration in recent years, are real enough. Yet its apparent impact in the last quarter century on the species I am dealing with has been remarkably small.

Turning to the political scene, it has to be noted that, despite agitation for the preservation of wetlands and other wildlife habitat by interested organizations, including provincial and federal wildlife agencies, and despite the existence of some appropriate legislation, neither the Government of Canada nor the Governments of Alberta, Saskatchewan and Manitoba, the custodians of the prairies, have seen fit to spend substantial sums of money on wetland preservation. Indeed most of the money they have spent on waterfowl-related matters in the last decade has been in the defense of farmers against the attacks of ducks and geese on swathed grain.

Back to duck numbers: what is the likelihood of substantial, and especially of catastrophic, decreases in the North American stocks of dabbling ducks if the intensification of agriculture in the Canadian prairies continues, if the climate remains the same or deteriorates, and if efforts at wetland conservation remain, as they do now, largely in private hands?

I do not believe that the stocks of North American dabbling ducks will be afflicted by catastrophic changes in the foreseeable future, whatever further damage may be inflicted on wetlands and their environs in the prairies or elsewhere. The ducks will continue to look after themselves, very capably, providing that we do not destroy their ability to do so by increasing our demands upon them unreasonably. That is to say, following Patterson (1979) rather than Rogers et al. (1979), I see recent attempts to argue that duck hunting is not having serious effects on waterfowl stocks as potentially mischievous, however scientifically respectable the scientific demonstration of its seeming lack of impact in the 1960s and early 1970s may have been. Recent levels of hunting intensity may not have been seriously damaging to dabbling duck stocks. They have certainly not been beneficial.

A hazard that I see in over-emphasizing the role of habitat alteration in determining waterfowl population size and success is one of human behavior. The future of wetlands will be determined by people who are not interested in them, many of whom are even less interested in waterfowl. We who are interested in waterfowl must certainly try to influence those activities of farmers and others which are in conflict with our interests, in every way that we can. But we must be careful not to relax our self-restraint, using the convenient excuse that it is the other fellow who is to blame for shortages. The sustained exploitation of renewable resources always requires restraint. Looking at other fields, such as marine fisheries, we can see how rarely the necessary restraints have been acknowledged, or are being achieved.

The ducks will look after themselves, just like other mobile animals, by moving about, and by changing their breeding schedules. Ducks are less adept than geese, but far quicker than people in adapting to changing circumstances.

In keeping with my concern with long-term trends, the pictures of change which I use here are based on moving averages, rather than the values for individual years. I avoid using the sums of the regional values as if they represented total populations because appreciable numbers of these ducks would be found outside the surveyed areas if anyone was looking for them in a systematic way.

I have grouped the strata used by the USFWS into five main regions: (1) Alaska; (2) the Mackenzie Basin and northern Alberta; (3) Northern Saskatchewan and Manitoba, representing the Canadian boreal zone; (4) the Canadian Prairies (southern Alberta, Saskatchewan and Manitoba), representing the parklands and former grasslands; and (5) the Dakotas, representing the southern extremity of the prairie pothole region.

The recent handbooks by Bellrose (1976) and Palmer (1976) have described the breeding ranges of the seven northwestern species of dabbling ducks in considerable detail, so that it comes as no surprise to find from the aerial surveys that, though their ranges overlap extensively, the relative abundance of the species differs from region to region.

Because numbers in the Canadian Prairies are generally higher than elsewhere in the sampled regions, absolutely as well as relatively, we have traditionally been especially interested in what is happening there. It has long been observed that the numbers of prairie ducks rise and fall with the wetness and dryness of the prairies. Though aerial surveys or other extensive measuring arrangements were not in use 40-50 years ago, duck numbers are believed to have fallen very low in the great drought of the mid-1930s. As noted earlier, the large numbers recorded (Figure 1) at the start of the aerial surveys seem to reflect water conditions more favorable then than at any other time in the last fifty years (Boyd 1981).

The most abundant ducks on the prairies—the mallard, pintail and blue-winged teal—have shown the largest fluctuations, keeping fairly closely in step over the 20-year period and all entering the 1980s at levels some 40 percent below those they attained in the "best" years but well above levels in the early 1960s. The American wigeon behaved rather similarly. The other three species were all more abundant around 1970 than they had been in 1955-1959, the green-winged teal and gadwall showing long periods of sustained growth.

Looking at the changes in duck numbers in the other four regions (Figure 2, Figure 3), the pictures are very different from those for the prairies. Numbers of mallard in northern Alberta and the Mackenzie Valley have fallen heavily while there was a boom in the Dakotas and in northern Saskatchewan and Manitoba in the late 1960s: the numbers in Alaska have risen steadily but slowly. The pintail has boomed in Alaska, particularly in recent years. It crashed in the Mackenzie Valley during the 1960s and only recently showed any sign of recovery. The American wigeon has gained greatly in Alaska and also in the far south of its range, in the Dakotas, as it did in northern Saskatchewan through the 1960s. In northern Alberta the opposite is true, with prolonged declines over much of the period.

The green-winged teal, a boreal breeding bird over most of its Holarctic range, has done well in Alaska, north Saskatchewan and, from a low base, in the Dakotas but shows wider fluctuations in northern Alberta and a lengthy decline in the Mackenzie Valley. The shoveler, relatively scarce in the boreal regions, has shown an increase in Alaska, as have most of the other dabblers.

Variations in northern duck numbers are unlikely to be a direct reflection of local water conditions, because the water balance shows a surplus of precipitation over evapotranspiration even in summer, except in peatlands (Lockwood 1976, Verry and Boelter 1978). The generally-accepted view amongst waterfowl biologists seems to be that the stocks of "northern residents" are fairly stable, with large apparent fluctuations being attributed either to the difficulty of detecting ducks consistently in forested areas or to influxes of "ex-prairie" ducks in years when the prairies are dry, which drop back to the prairies when they are wet again. For several good practical reasons there are very few hard facts with which to test hypotheses about these temporary displacements. It may be a mistake to depend too heavily on the notion of prairie wetness driving duck numbers up and down in the north as well as on the prairies themselves. So I have begun to look more carefully into climate variation and its impact on ducks in the boreal zone itself.

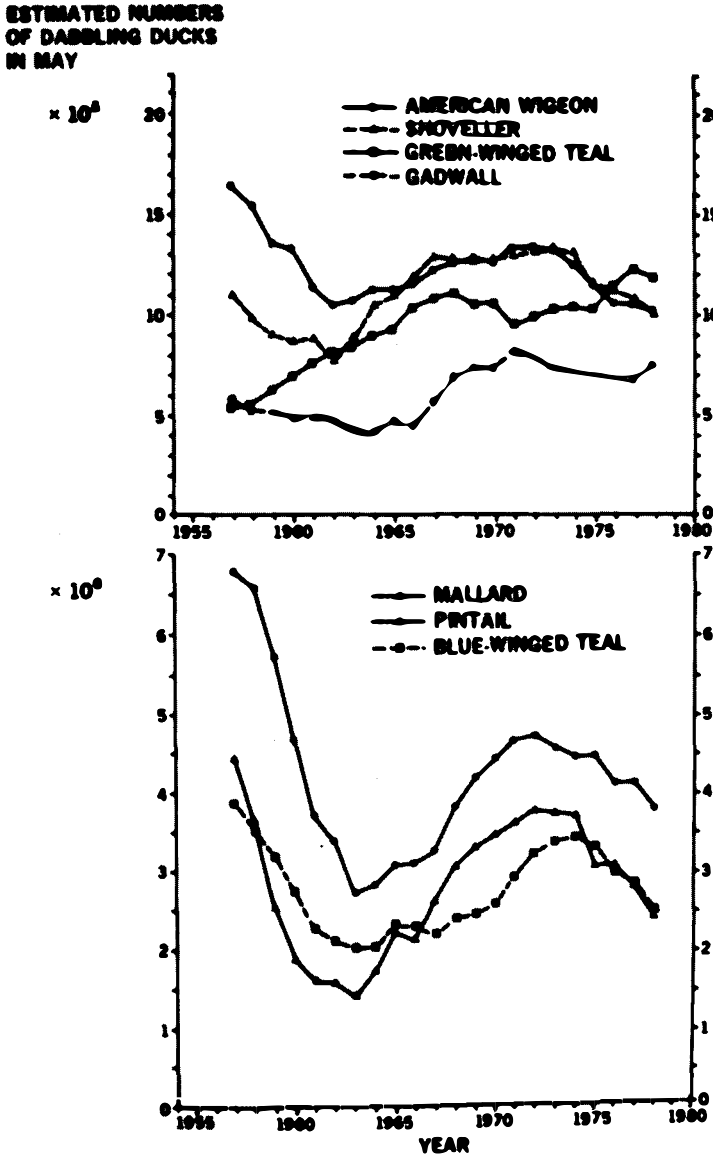

Figure 1. Breeding pairs of seven species of dabbling ducks in the Canadian prairies, 1955-1980, shown as five-year moving averages.

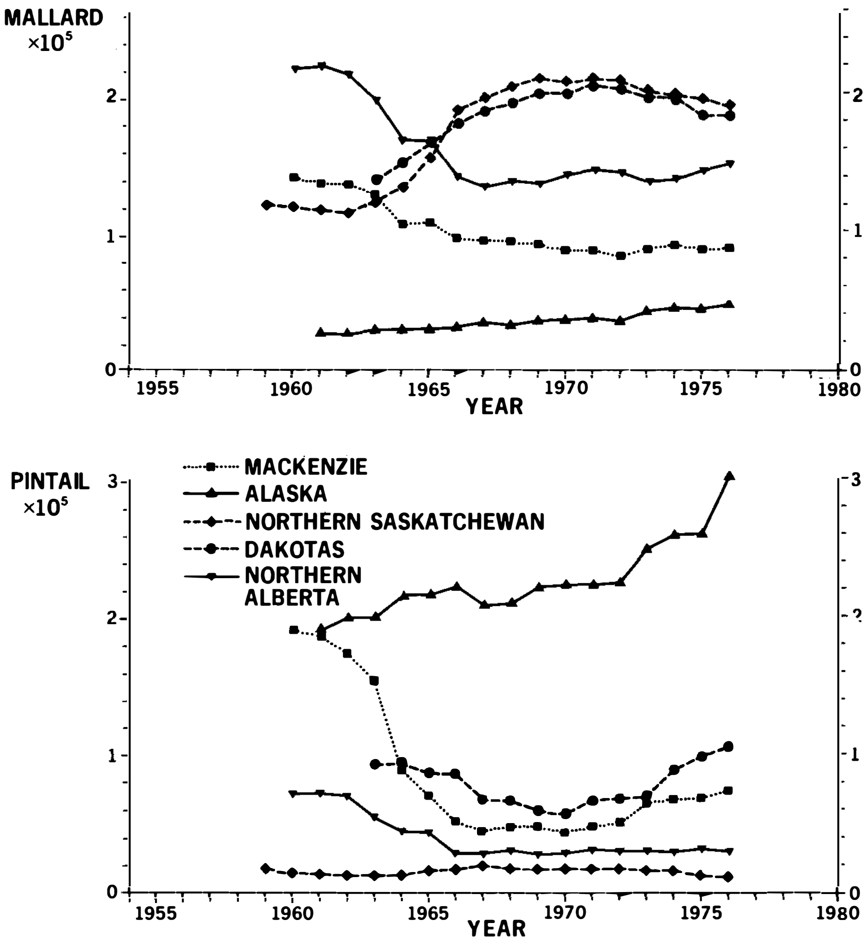

Figure 2. Breeding pairs of mallard and pintail in northwestern regions other than the Canadian prairies, 1955-1980, shown as nine-year moving averages. (The surveys of some regions did not begin as early as 1955.)

It has long been known that boreal weather is at least as variable as weather further south, especially over the transition zones between the forest and the tundra to the north and from the forest to the parklands in the south (Bryson 1966). My provisional findings are that the intrinsic characteristics and production of northern stocks are more important than over- or under-flying of prairie ducks in accounting for increasing numbers in Alaska and dwindling numbers in the Mackenzie Basin (Boyd 1981, and in prep.). So far as Alaska is concerned, over-flying by prairie ducks might account for most of the observed changes in pintails and perhaps American wigeon, but not for the mallard, green-winged teal and shoveler. I have yet to find a satisfying explanation for the falling numbers in the Mackenzie Basin.

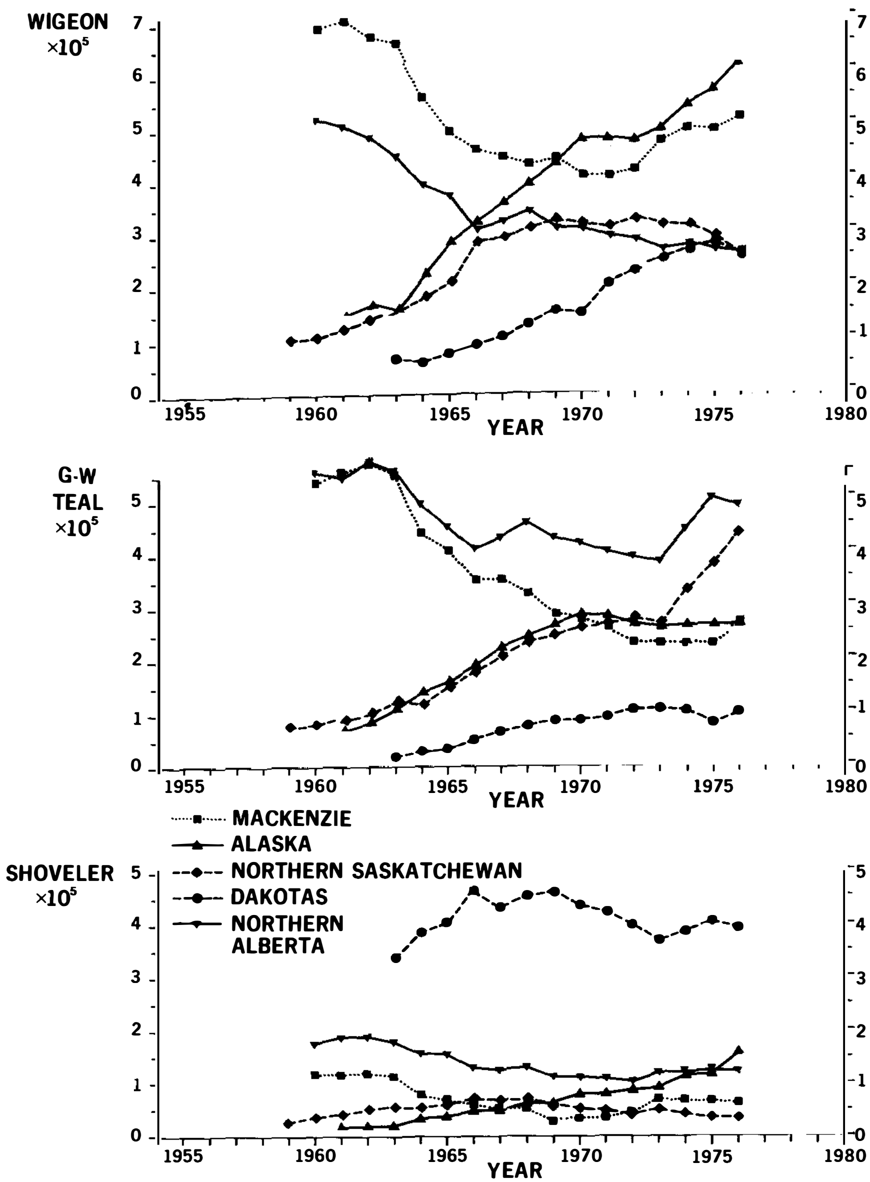

Figure 3. Breeding pairs of American wigeon, green-winged teal and shoveler in northwestern regions other than the Canadian prairies, 1955-1980, shown as nine-year moving averages.

Description without causal analysis is of course less than ideal for the purpose of deciding on management strategies. But it may be all we can do. We are faced with the dilemma that confronted economists some fifty years ago when they realized that national and international economic planning could not be based on simple extrapolation from the theory of the firm. There are many parallels between the needs and problems of macro-economics and those of continental waterfowl management. We have to learn how to make sensible decisions on the basis of weak inferences, as economic managers must do (Hicks 1979), because the systems we are attempting to manage are too complex and ill-defined to be handled by orthodox scientific methods. This does not at all mean that we should be content to rely on skill in riding political waves, rather than on biological understanding, though both have a part to play.

I recently heard it suggested, by a spokesman of some weight, that the U.S. Fish and Wildlife Service and the Canadian Wildlife Service have spent too much time and effort in counting ducks and not enough in trying to manage them. I emphatically disagree. We have not done enough counting of ducks. In Canada we are especially in need of more quantitative data on the distribution of ducks during the hunting season, which is very different from the breeding distribution. Knowledge of both is necessary for sound management.

Let me summarize my main themes. First, the seven principal dabbling ducks of northwestern North America have shown over the last quarter of a century all the variability in regional abundance that should be expected from highly mobile animals attuned to living in fluctuating environments. That being so, the enthusiasm now being shown in the western provinces for the establishment of numerical objectives and goals for the management of duck populations seems likely to prove futile and absurd, as is generally true both of planning and of affairs of the heart.

My second point is that the adverse impacts of human activities, whether wetland destruction or deaths due to hunting, have been far smaller than most of us would have believed likely twenty five years ago. None of the dabbling duck stocks has declined to dangerously low levels, though some can now yield a much smaller harvestable surplus than formerly. Even in the farmed parts of the western Canadian provinces it seems likely that the numbers of ducks will not be appreciably fewer in 1990 than they were in 1980, unless a sustained drought as severe as that in the 1930s, or perhaps that in 1981, is occurring at that time.

Third, a great deal of resilience remains in these dabbling duck populations. That being so, the reluctance of Canadian governments to spend money on wetland preservation in those parts of the western provinces well suited to agriculture may have been sensible, from the point of view of Canadian waterfowl management, even though it seems likely to have been damaging to the countryside in a wider ecological view. Fourth, the mechanisms controlling the numbers of dabbling ducks in the boreal zone remain obscure. Despite the relative lack now and in the near future of human impact on the boreal region, except in northern Alberta, the north seems likely to provide no safer a future home for dabbling ducks than the transformed prairies. Yet North Americans will remain fortunate in continuing to share their continent with many ducks. Finally, and most importantly, "whatever earthquakes and upheavals may be afflicting the general public" the ducks will stand aloof from them and just go on being ducks, just as P. G. Wodehouse said.

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Waterfowl Management and Waterfowl Disease: Independent or Cause and Effect Relationships?

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Introduction

"The North American continent at one time was blessed with a wealth of wildfowl beyond that of any country in the world. In the spring and fall with the regularity of the seasons a great army of ducks, geese and brant winged their way across the country, and they do so now in sadly diminished numbers" (Bruette 1947: 1). This 1947 quotation from the opening sentences of a book on waterfowl hunting reflects a comparison between that time and that of the earliest settlers. The implication is that we should restore waterfowl numbers to those previous levels. Although modified in concept, increasing waterfowl numbers is a common goal of today's waterfowl managers. There are many obstacles to achieving this goal, one of which is disease.

Disease has been known to occur in North American waterfowl for over a century (Friend 1981). The diversity and types of disease problems present today differ somewhat from those recognized in the past. For example, avian cholera was unknown in North American waterfowl before 1944 (Quortrup et al. 1946). Duck plague or duck virus enteritis (DVE) was not recognized in the United States until 1967 (Leibovitz and Hwang 1968) and the first major epizootic involving wild waterfowl did not occur until 1973 (Friend and Pearson 1974).

I am not suggesting that disease has been a major factor in the decline of continental waterfowl populations. Instead, I draw your attention to the fact that current waterfowl populations are subject to different disease problems than those of historic waterfowl populations. It is important to view the characteristics of these new diseases in a perspective that relates to waterfowl population goals and management methods for achieving those goals. This presentation will focus on whether waterfowl management and waterfowl disease are independent factors, or represent cause and effect relationships.

Disease Perspectives

A popular wildlife management textbook of nearly three decades ago groups disease, climatic disturbances, and predators as causing unpreventable losses in waterfowl (Trippensee 1953). This concept of disease as a "natural phenomenon," something that just happens irrespective of our actions, and something over which we have little or no control, has persisted as a viewpoint among many biologists and other resource managers. Although this concept may be true in some instances, the consequences of man's actions, and sometimes his inaction, can be important in the development of disease problems.

Increased awareness of diseases of waterfowl has resulted in more consideration toward disease than ever before. For example, Sanderson (1978: 43) noted that waterfowl conservation embraces four distinct entities: (1) habitat preservation and enhancement, (2) harvest regulations that permit the highest kill commensurate with the capability of the species to replace these losses, (3) control of disease, and (4) propagation.

Although this increased awareness has fostered a more reactive posture to disease, it has not resulted in increased attention to the relation between disease problems and management practices.

I perceive four basic levels of response to disease problems (Table 1). Currently, management philosophy toward disease has only evolved to the initial stages of the third level. At the first level, there is little more than awareness that disease exists. This can be equated to the perspective of Primitive Man to his world. "Primitive Man took a quite fatalistic view of life, death and that gray area of disease that lies between. Sickness, although mysterious, was too familiar to be regarded as a mystery. It was a part of nature and therefore, a part of life. It was something to be endured," (Cannan 1965: 7). For too long, many resource man-

Table 1. Evolution of management response to wildlife disease problems.

Level	Response characteristics	Stage	Perspective towards disease
1	Recognition that disease exists; acceptance of disease as a natural event.	Awareness	Fatalistic
2	a. Desire to respond to die-offs; no action taken because none obvious. b. Generate concern to others.	Concern	Frustration
3	a. Responses to die-offs in an unplanned manner. b. Plans developed and utilized in responding to die-offs. c. Improved method developed for combatting die-offs. d. Control efforts evaluated for effectiveness.	Control	Fire fighting
4	a. Reaction procedures well organized, effective within limitations of capabilities; prevention of future outbreaks given attention. b. Short-term research carried out for disease control; long-term research initiated for disease prevention. c. Disease concepts integrated as part of routine wildlife management; integrated program of research and disease control underway.	Prevention	Problem solving

agers accepted waterfowl disease problems as a "part of nature" and, therefore, "something to be endured." Most, however, have now made the transition beyond this level.

At Level Two, awareness of disease problems is translated into concern and a desire to do something, but no actions are taken because no corrective course of action is evident. Expression of concern is often the final limit reached due to a lack of confidence that anything constructive can be done. A significant number of resource managers continue to have this perspective toward disease problems.

At Level Three, concern is elevated to an attempt to control disease. Tools are developed in response to situations that arise, and for the first time there is an attempt to take "thought and action" as a means for combatting disease outbreaks. More and more waterfowl managers are reaching this level. However, the posture is largely reactive and represents "fire fighting" efforts focused against symptoms, rather than causes of problems. This is also the most costly level for combatting disease.

For the most part, Level Three is "treating the patient after the problem develops" rather than preventing the problem from occurring. Leopold (1933: 325) pointed out the fallacy of this approach by noting that "doctoring is of recessive importance in health control even in domesticated species and human beings."

It is not until Level Four is reached that effective, long-term mitigation of disease problems can be obtained. At this level, prevention of the problem is the ultimate goal. The key to reaching this level of understanding is well-planned, long-term research, since a thorough understanding of disease processes and the causes of specific disease problems is required for success. Initial costs are high, but the long-term benefits make Level Four far more cost-effective than Level Three. One only needs to reflect on the tremendous annual costs associated with combatting poliomyelitis and smallpox in man during past years to appreciate the cost-effectiveness of achieving Level Four status.

Diseases of Waterfowl

Presently we recognize four diseases as having the capability to inflict heavy losses among North American waterfowl; avian cholera, avian botulism, duck plague, and lead poisoning. Avian botulism and lead poisoning are toxic processes and have been recognized as problems for many years. Avian cholera and duck plague are caused by infectious agents and are of more recent origin in North American waterfowl.

As a group, infectious agents are more difficult to combat than toxicants because of the potential for rapid spread of infection through a susceptible host population and thus pose a greater potential for causing catastrophic losses. Peak mortality exceeded 2,000 birds per day during the 1980 avian cholera outbreak in Nebraska's Rainwater Basin. Peak losses of more than 1,000 birds per day have also occurred in other avian cholera outbreaks and in outbreaks of duck plague. This magnitude of loss has occurred in the presence of disease control activities, attesting to the difficulty of combatting infectious disease problems in waterfowl. Other infectious diseases will undoubtedly become important in the future, further establishing infectious diseases as formidable problems to be dealt with.

Avian botulism has been the cause of the most massive losses from disease known to occur in waterfowl (Kalmbach 1968). Although caused by an intoxication, transmission is similar to infectious diseases. Maggots and other invertebrates feeding on animal carcasses containing botulinum toxin serve to intoxicate birds that feed on them and a single carcass serves as the focal point for spreading the disease to many birds. However, unlike infectious diseases, management techniques have been developed for preventing and controlling this disease (Rosen 1971). These techniques have been moderately successful on areas where they can be applied, but for many other areas avian botulism continues to be a significant problem.

Mortality from lead poisoning is of a chronic nature, losses are spread over a longer period of the year, and the problem occurs over a broad geographic range. Although a great number of birds die, losses from lead poisoning are less visible and more easily prevented than those for botulism, avian cholera, and duck plague. The controversy involved in implementing management actions to mitigate losses from lead poisoning is indicative of other controversies that will arise in the future as other types of nontraditional disease control measures are implemented.

Habitat Perspectives

Habitat preservation and enhancement are generally considered to be the most important aspects of waterfowl conservation. We are all aware of the significant loss of wetlands that has occurred in the United States and to a lesser extent in Canada. Currently, the annual loss of wetlands in the United States is estimated to be 300,000 acres (121,410 ha). Despite habitat losses, management goals are generally oriented at producing and maintaining increased numbers of waterfowl. This will require producing and maintaining more birds on less habitat or significantly reducing annual mortality among waterfowl populations.

Originally, there was an estimated 127 million acres (51.4 million ha) of habitat (both fresh and salt water) available to waterfowl in the United States. By 1968 only 74.4 million acres (30.1 million ha) were available, of which approximately 10 percent was considered high-quality, 18 percent of moderate value, 32 percent of low value, and the remaining 38 percent had negligible value (Sanderson 1978). This recognition of habitat quality as well as quantity relates to the biological needs of waterfowl. Habitat quality is also important for pathogenic agents of disease, a point that will be discussed later.

The essential ingredient for wetlands is water, but unfortunately, the amount of water available is a finite quantity, and like the air we breath, nearly all life depends on it. Therefore, the perspectives elucidated by Ezra Taft Benson 26 years ago are worth repeating since they represent reality now and for the future. "I have little need to remind you that water has become one of our major national concerns. . . . The subject of water can be viewed from the various aspects of soil conservation, agronomy, forestry, irrigation, wildlife, recreation, business, industry, law and so on—but never alone. . . ."

The volume, location, time of year water is available to waterfowl, and water quality are important factors. Quality of course is relative and depends on the purpose for which the water is used. Water suitable for industrial and agricultural purposes is not suitable as drinking water for the human population. In most instances, the use of water for wildlife is not an exclusive process, but instead represents a reuse of water from municipal, agricultural, or industrial sources. The question that must be considered is: How suitable is this water for waterfowl?

Management Perspectives

The concept of disease as a "natural phenomenon" unrelated to management practices must be examined in relation to the causes of disease. Leopold (1933: 326) placed this in perspective by noting that, "the real determinants of disease mortality are the environment and the population, both of which are being 'doctored' daily, for better or for worse, by gun and axe, and by fire and plow." Environmental manipulation is the backbone of waterfowl management. Therefore, it is evident that we are "doctoring" both the environment and the populations to which Leopold referred. An important question is: What effects are these actions having on the development and maintenance of disease problems of waterfowl?

It has been stated that, "Man's impact on waterfowl has been essentially negative, and the problems that humans create for waterfowl are such that they will undoubtedly get worse before significant improvement is achieved (even though waterfowl as a group have probably been protected and managed more by man than any other form of wildlife)" (Todd 1979: 341). The negative aspect of man's impact on waterfowl includes the development of disease problems, primarily by default.

Failure to recognize or accept the concept that land and water management practices can influence disease processes, and the consequences of not adequately addressing infectious disease problems is well demonstrated by the current distribution of avian cholera in North American waterfowl. Before 1944 this disease was unknown in wild waterfowl; today it is one of the most devastating diseases encountered. The Central Valley of California, the Texas Panhandle, and Nebraska's Rainwater Basin have all developed into avian cholera enzootic areas (Friend 1981).

Lack of action toward infectious disease has not been paralleled by actions toward problems caused by environmental pollutants. A probable reason is that pollutants are recognized as a direct result of man's actions and the resulting impacts accepted as cause and effect relations that can be dealt with.

However, failure to associate man's actions with development and maintenance of diseases caused by non-chemical agents ignores the fact that, "it is only in the most advanced societies that civilized man, through the science of modern medicine, begins to approximate the good health the world's least civilized people enjoy as a birthright" (Dubos and Pines 1965:16). It is not unreasonable then to conclude that many diseases have a strong environmental basis. If this is true, and we recognize that environmental manipulation is the fundamental concept of wildlife management, we should also be able to recognize that environmental manipulation has a relation to disease processes.

Relations between environmental factors and maintenance and spread of waterfowl diseases are readily apparent. For example, water depth and distribution influence ingestion rates of lead shot, and lead toxicity is influenced by diet (Greenwalt 1976). Specific environmental conditions required for type C botulism include high temperatures, anaerobic conditions, and a suitable nutrient medium (Rosen 1971). Also, the microenvironment of wetlands may be one of the most critical factors for the perpetuation of infectious diseases such as avian cholera and duck plague.

Viruses and bacteria shed into wetlands must survive long enough to infect a new susceptible host if the disease process is to be continued. These organisms have finite life spans which are greatly influenced by physical and chemical variables of the environment; e.g., under laboratory conditions the virus causing duck plague is inactivated at a pH below 3 or above 11 (Dardiri et al. 1967).

Environmental persistence of *Pastuerella multocida* may be a major factor in the magnitude of avian cholera losses in Nebraska's Rainwater Basin, the Playa Lake region of the Texas Panhandle, and in the Central Valley of California. Heavy losses from avian cholera reoccur in the same wetlands within these areas, whereas only small losses occur in nearby wetlands. Habitat quality, as it relates to the microenvironment, appears to be the important difference.

Management—Disease Interrelations

North American waterfowl represent a resource of considerable economic value beyond their purely aesthetic attributes. There are at least 3 million hunters who actively hunt waterfowl in the United States and another 400,000 in Canada. These hunters make up a significant percentage of the 16 million licensed hunters who spend $2 billion in pursuit of their sport in the United States (Todd 1979). Given this degree of interest and economic attachment to this resource, our efforts to sustain and even increase current waterfowl populations are understandable. However, as previously noted, achievement of this goal will require the production and maintenance of more waterfowl on less habitat. The critical question is: Can this be done?

North American hunters (excluding Mexico) are currently harvesting about 20 million waterfowl annually (including crippling loss). Nonhunting mortality equals annual hunter harvest. Disease accounts for the largest proportion of this loss (Bellrose 1978). Waterfowl populations of historic times had a greater capacity to withstand losses from disease than present or future populations. Infectious diseases that could strike birds anywhere along their migratory pathways from the breeding grounds to their wintering grounds were unheard of and the amount of habitat available allowed waterfowl to freely move about, thereby reducing the potential for exposure to disease problems that did occur.

A different situation exists today. Historic migration patterns have been significantly altered in many instances. Waterfowl are intentionally held in large concentrations for prolonged periods of time in limited areas by management actions. In other instances, traditional migrants are inadvertently encouraged to remain in northern areas for prolonged periods due to the creation of suitable habitat by dams, power plants, and other changes in land use patterns. In addition, habitat loss has resulted in large segments of discrete waterfowl populations being concentrated on limited staging areas. The recent establishment of infectious diseases within our waterfowl populations makes this situation even more untenable.

Transmission of infectious disease is facilitated by the concentration of waterfowl at site-specific locations. Development of disease carriers among survivors provides a mechanism for spreading diseases to other locations, as well as reintroducing the problem when survivors return the following year. Therefore, the relation of disease to management practices must be both understood and considered if irreversible detrimental impacts are to be avoided.

Although there are no simple solutions, there are some basic considerations. Among them is the strong relation between environmental quality and disease. This is not a new concept; Leopold (1933:339) stated that, "Disease control is a matter of doctoring the environment, not the animal." However, "One of the least appreciated influences on disease is environment" (Dubos and Pines 1965:16). In this regard, it is not sufficient to consider waterfowl habitat needs only in quantitative terms. Unless habitat quality is properly considered, we are likely to develop death traps for waterfowl and other migratory birds as we pursue acquisition and development projects.

Waterfowl management at site specific locations involves three basic components over which we have some degree of control: (1) bird numbers, (2) length of time the area is utilized, and (3) amount of available habitat. Each of these has significance relative to disease, but the contributions of each are at best poorly understood. Further, these components are interrelated rather than mutually exclusive and are influenced by a number of external factors such as weather, water quality, and bird movement patterns.

Inclement weather can serve to crowd birds together, reduce activity patterns, and may provide a "stress" that precipitates eruption and transmission of infectious diseases such as avian cholera. Waterfowl managers must consider this scenario in the development of flyway management plans. The maximum number of birds is a question that must be considered. The answer involves time of year, geographic location, and proportion of discrete population segment present, as well as other considerations.

Waste water from treated sewage provides a potential means for increasing the amount of waterfowl habitat available, especially in more arid parts of the United States. In addition, sewage outfalls are often popular waterfowl feeding areas and sewage lagoons are used as resting and loafing areas. An adequate assessment of the safety or hazards associated with use of waste water for waterfowl habitat has not yet been made. This must be done so that if disease risks are acceptable, full utilization of this water can be realized, or if risks are unacceptable, appropriate disease prevention measures can be developed.

Disease concerns regarding introduction of pathogenic organisms into wetlands by waste water at threshold levels for infection of waterfowl have a parallel in waterfowl use patterns. Birds and other animals surviving infectious diseases may become carriers of those causative organisms. They may then shed these organisms into the environment around them. When susceptible birds are exposed to the number of organisms required to initiate infection, clinical disease occurs and a disease outbreak may follow as a result of amplification of the number of organisms shed into the environment.

Fecal discharges are one means of a carrier shedding pathogens into an environment. The average per capita contribution of fecal coliforms per 24 hours in the feces of domestic ducks was found to be 5.5 times that of man, almost 50 times that of chickens, and almost 90 times that of turkeys (Geldreich 1966). Serious thought must be given to the impact of these fecal discharges when waterfowl utilize small, shallow, and sometimes stagnant bodies of water for prolonged periods of time. Direct transmission of disease and changes in the quality of the microenvironment that may favor survival of pathogenic microorganisms are considerations waterfowl managers must be aware of.

Conclusion

The primary conclusions I hope you have reached are that: (1) disease problems do not just happen, (2) there is a strong relation between environmental quality and disease, (3) disease is often the end product of a complex chain of biological events, and (4) sound waterfowl management requires adequate consideration of disease as part of the management process.

Our current level of understanding of waterfowl disease is in its infancy. We are beginning to ask the right questions, but the answers will require long-term research efforts. In the interim, it is critical that we use existing knowledge wisely and completely. Waterfowl management and disease problems are seldom independent events and should not be treated as such.

Observations by Phillips and Lincoln (1930) a half-century ago are essentially true today, however, we must now include disease in reflecting on those observations.

> Unless the more intelligent sportsman can be made to give serious and immediate attention to the many adverse factors which to-day confront our most valuable wild-fowl, we believe it soon will be too late to save these birds in numbers sufficient to be of any real importance for recreation in the future. (p. xiii) Conservationists, the optimistic ones, may look forward to the day when we may provide for a greatly increased stock of wild-fowl, but this day is not in sight. The best that we can do, faced as we are with an ever-lessening area of optimum feeding and breeding grounds, is to ensure the maintenance of what stock we have left. Even this would be, in our opinion, a very considerable feat of accomplishment (p. 237).

Whether we like the analogy or not, waterfowl management in many areas of the United States parallels intensive domestic animal production. This trend is likely to expand and intensify in the future as resource managers attempt to provide enough waterfowl to meet increasing demands for their utilization while faced with further reductions in waterfowl habitat. The result is likely to be further increases in disease problems among waterfowl.

The transition from raising cattle on open-range to raising them in feedlots, and from raising poultry in backyard and range flocks to raising them in large intensive production units has resulted in a variety of new disease problems and increases in some old ones. This is a direct result of changing environmental conditions associated with changes in animal husbandry and production management.

Pasture and range rotation is not provided to "cleanse the environment" under these intensive management systems. As a result, pathogenic microorganism and parasite loads can build up. In addition, the dense concentrations of poultry and livestock present at site-specific locations alter the environment in a manner that increases potential for aerosol transmission of disease; these densities also facilitate the rapid transmission of disease. Vaccines and other veterinary biologics are relied upon to prevent disease and control outbreaks that do occur.

The similarity to waterfowl management cannot be ignored. Habitat losses have been combatted by the acquisition and development of a myriad of private, state, and federal refuges as well as other wetlands where waterfowl congregate for various periods of time. The level of concentration will continue to intensify in the future as attempts are made to maintain more waterfowl on less habitat. These birds will also be retained on the remaining habitat for longer periods of time, thereby reducing the "cleansing" of the habitat.

Waterfowl alter their environment in a manner that facilitates the maintenance of disease problems as a result of their presence, and disease transmission is facilitated because of their gregarious behavior. New diseases have occurred in recent years, and old disease problems continue to take their toll. A major difference between waterfowl and domestic animal husbandry is that we do not have the same capability for applying veterinary biologics to alleviate disease problems. In addition, we have not yet developed sound management practices for preventing the establishment of serious disease problems at site-specific locations.

Waterfowl management and waterfowl disease are seldom independent events. Recognition of this concept is essential if we hope to maintain waterfowl population goals that will provide for the recreational and aesthetic needs of current and future human populations.

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Strengthening Private Lands Management

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The Farmer and Wildlife

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An examination of the policy statements of the Farmers Union suggests that all is not well between farmers and those who generally support wildlife preservation.

The Farmers Union is a general farm organization, representing the interests of producers of all commodities (as distinguished from a commodity organization which makes its appeal to members on the basis of their interest in a single commodity, such as wheat or hogs). Farmers Union policy is made at many levels in the organization. A resolution may be adopted at a local or county meeting; a delegate from that group may succeed in persuading the state convention to adopt the resolution; and finally, the resolution, or a variation of it, may find its way into the policy which is adopted in the annual convention of the National Farmers Union.

The policies of the Farmers Union—like those of other general farm organizations—deal with a broad spectrum of issues. Any issue affecting the members is likely to be considered, and a statement adopted. The policy statements of the Farmers Union indicate that wildlife preservation is a matter of concern to its members. And although members are concerned about "conservation of our land, water and air," and want to maintain "ecological balance," they often appear to be at odds with those who favor the creation of wildlife sanctuaries and habitats. The policy of the National Farmers Union emphasizes repeatedly the need for maintaining ecological balance and conserving water, land and air.

References in this paper to policy positions of the National Farmers Union and its state organizations are taken from most recently available printed statements, all of which were adopted in late 1979 or in 1980.

The Arkansas Farmers Union reflects widely held opinion in the organization when it says, "The protection of our natural resources is a matter of urgent and continuing need." It is not just the interests of farmers that the Arkansas Farmers Union would protect, but people generally: "We believe regulation and control of land in the interest of people is essential if real progress is to be made in achieving a quality of life for all Americans."

The South Dakota Farmers Union is the only state Farmers Union with an explicitly kind word for the "hunting industry," and acknowledges that it "has been of great economic importance to South Dakota." But that reference may have more than one purpose, because the policy goes on to say: "We believe the best interest of the public will be served by having the Department of Game, Fish and Parks accountable to the State Legislature, and will support legislation to this end."

Farmers are hunters too, of course. But not all hunters meet their standards, it appears. The Ohio Farmers Union says: "We recommend that the Division of Wildlife and all sportsmen's organizations conduct education programs for the licensed hunter, emphasizing the importance of hunting laws and hunting techniques."

The Pennsylvania Farmers Union would go a little further and would require hunters "to have written permission from the landowner or his agent to hunt or trap on privately owned farmland and the woodlots encompassed in the farm boundary." Furthermore, Pennsylvania members want current liability regulations protecting the landowner to remain in force undiminished, notwithstanding the written permission. "These regulations shall be enforced by the Game Commission," says the policy.

The Oklahoma Farmers Union asks that the following requirement be printed on the back of licenses: "This license will be canceled by any game warden if the holder violates the present law of hunting and fishing on private property without permission from the owner, landlord, or operator. It is hereby understood that the owner of the property is not responsible for any accident or injury sustained by persons entering land with or without permission."

The Minnesota Farmers Union says: "Landowners should not be held liable for accidents to hunters or recreational participants, such as snowmobilers trespassing on their property. It is the inherent right of property owners and tenants to retain control over access to property."

The Rocky Mountain Farmers Union asks simply that "the trespass laws be more rigidly enforced."

It is not just damage to and by hunters that concerns farmers, but damage by wildlife itself. The South Dakota Farmers Union statement says, "We recommend that all restrictions be removed from both jackrabbits and cottontails, so sportsmen and others can help diminish their population and thereby prevent further damage to trees and gardens, etc., in South Dakota." Animals that damage crops differ from state to state. Deer do a lot of damage in Pennsylvania, and the Pennsylvania Farmers Union tries to get at the problem in several ways. The organization wants to "allow farmers to keep deer killed because of crop damage, whether the land is posted or not." The organization recommends that the Pennsylvania Game Commission develop a program to compensate farmers for crop damage by wildlife when losses over $100 are verified by the County Extension Service. The Pennsylvania group opposes protection of blackbirds, crows, English sparrows, starlings and grackles. It also opposes legislation that would outlaw the use of leg-hold traps.

The Rocky Mountain Farmers Union says: "Inasmuch as wild game does considerable damage to crops, we would ask that more equitable damages be paid by the Wildlife Division, unless the landowners or lessees are collecting a bounty or fee."

On the other hand, the Rocky Mountain group requests the Wildlife Division to close the season for hunting game wildlife in areas where game wildlife "are being depleted." In addition: "Because farmers and ranchers feed much of the wild game on private lands, we request legislative relief by permitting the farmers and ranchers a free license to hunt the legal limits on his own land, as is the practice in other states."

The Iowa Farmers Union says: ". . . . the deer population in Iowa is getting so heavy that it is very destructive to farm crops, (therefore) we recommend that deer hunting restrictions be lifted during deer seasons for all land owners and tenants on their own property."

The Michigan Farmers Union favors "payment to farmers for deer damage done on their cash crop fields, such as potatoes. This payment to come through the ASCS office."

The Oklahoma Farmers Union urges "the Oklahoma Legislature (to) continue to appropriate monies to provide for the eradication of crows, blackbirds and predatory animals in areas where they have become a menace and destructive to crops and livestock. We oppose the importation into Oklahoma of any mammal, fish, or reptile that may become a pest."

Coyotes are the source of much complaint. The Montana Farmers Union supports "the use of the state helicopter to help control predators, especially coyotes." The statement continues: "We are opposed to any legislation which would ban aerial hunting, steel traps, M-44's and other approved methods, or take coyotes and foxes off the predator list and classify them as furbearers. Problems relative to hunting, trapping, poisoning, snaring of foxes, coyotes and raccoons should be called to the attention of the appropriate state officials, and legislation, if necessary should be prepared to handle these problems. We favor limited protection for the grizzly bear so it does not become extinct, but not to the extent than an individual cannot protect his life or property."

It is not just wildlife, but the habitat itself which is costly to farmers. The Pennsylvania Farmers Union recommends that "the propagation and sale of multiflora rose be outlawed within the Commonwealth of Pennsylvania." The South Dakota Farmers Union statement says: ". . . . full consideration should be given to properly compensating landowners for wildlife habitat. . . ."

Farm residues such as straw, weeds along irrigation canals and fence rows, are generally regarded as good cover for wildlife. But such covers can be a problem for farmers. The Rocky Mountain Farmers Union says: "We encourage the right of the farmers to be allowed to burn all vegetation waste along fence lines, irrigation ditches, and fields without permits." The New Mexico Farmers Union also encourages "the right of the farmer to be allowed to burn vegetation wastes."

Wildlife areas can be a source of noxious weeds, and the South Dakota Farmers Union says: "Firmer regulations should be adopted to control all weeds on all lands held by private owners and the United States government." The Minnesota Farmers Union says: "We ask for more effective government control of weeds on railroad right of ways, waterfowl production areas, and other public lands, as well as better private control of weeds. On the other hand, the Nebraska Farmers Union calls for shelterbelts to provide wind breaks "and animal shelters."

There are direct costs of habitat, and the encroachment of habitat on productive farm lands is seen as another type of cost. The South Dakota Farmers Union statement says: "We oppose the aquisition of productive farm land to extend wildlife habitat." The Indiana Farmers Union says: "We urge that federal, state, and local governments be prohibited from condemning large acreages of fertile and productive farm land for the purpose of wildlife refuges or recreation."

The National Farmers Union puts the issue this way: "We oppose the aquisition of productive farmland through use of the eminent domain process to extend wildlife habitat. The arbitrary designation of portions of farm units for wildlife propagation on land designated for wildlife mitigation, without negotiation with a willing farm operator, is disruptive and destructive to the efficiency of family farm management. Land to extend wildlife habitat should be acquired only by negotiation with a willing seller."

It seems evident that farmers don't feel they have enough influence in such matters. The South Dakota statement parallels the national statement almost exactly with reference to "arbitrary" designation of land for wildlife mitigation. "Arbitrary" decisions are those which do not include farmers, or their representatives. That, in fact, is the major concern of the Arkansas Farmers Union which asks that "family farmers" be "adequately represented on boards and commissions dealing with matters of zoning and land purchase, leasing and transfer to aid in recognizing that agricultural land must be preserved for the future." The Pennsylvania Farmers Union says: "We recommend that at least two farmers who derive at least 75 percent of their income from farming be appointed to serve on the Pennsylvania Game Commission to help express the farmer's viewpoint on farm problems caused by game regulations."

These statements indicate that the farmer is concerned about the costs of wildlife—the costs of damage, the costs of maintaining habitat, as well as the long-term costs to society of removing habitat land from production.

The Minnesota Farmers Union has a constructive recommendation for reducing the problems. Its policy says in part: "Federal and state conservation and wildlife agencies should be authorized to reimburse farmers for losses due to protected wildlife feeding on farm crops and livestock. These agencies should buy grain for their wildlife feeding operations from farmers in the immediate area. As an alternative approach, consideration should be given to a government supported insurance for farmers against crop depredation by fowl or animals. Rather than acquire ownership of further land for wildlife habitat, we urge that the state only lease the land for a limited time so that it remains on the tax rolls."

To extrapolate somewhat from the foregoing recommendations, it would seem advisable to consider integrating wildlife preservation into the nation's crop insurance and cost-sharing conservation programs. Wildlife preservation appears to be as much a cost to the farmer as conservation of topsoil. If wildlife is preserved, damage to the farmer's crops and livestock seems inevitable. Why not make the cost of habitats a part of cost sharing under the Agriculture Stabilization and Conservation Service? Why not make losses that result from damage by wildlife to crops and livestock a part of the all-risk insurance program? Wildlife preservation advocates might gain an important and necessary ally in the farmer by supporting such measures.

Management by Objectives

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Introduction

Today's North American farmer is recognized as history's most efficient agricultural producer. To more fully appreciate how wide a gap exists between the modern farmer and his counterparts in less developed parts of the world consider these facts:

— China, the world's most populous nation, must employ 80 to 85 percent of its people in farm labor just to feed itself. That's a work force about three times larger than the entire combined population of the United States and Canada. By contrast, only about two percent of the United States population is directly engaged in agricultural production—and just one American in 26 lives on a farm.

— Livestock production in North America is vastly more efficient than in other parts of the world. Sixty percent of the earth's ruminant animals are found in developing nations—and yet in the United States an equal quantity of human food is produced from just 8 percent of the world's total ruminants.

— The grain production gap is even greater. Both India and the United States produce about 70 million bushels of grain sorghum annually. Yields are far higher here than in the Asian nation. It takes six times as much land in India to match the United States crop! Weed control in this country is accomplished primarily through the use of agricultural chemicals and power machinery, requiring an average of about two man-hours per acre. In India, weed control demands 500 hours of hand labor per acre!

— While the average United States farm worker is credited with providing food for nearly 65 persons, the productivity of many individuals is far higher. For example, it's not unusual for an automated dairy to annually turn out as much as 750,000 pounds (340,000 kg) of milk per man. That's enough to satisfy the total needs of about 1,500 Americans for fluid milk and processed dairy products.

— The North American consumer spends a smaller portion of his income for food than people in other parts of the world. Despite that, Americans and Canadians enjoy one of the most abundant diets in history.

Still, today's North American farmer and rancher is faced with an economy that threatens his, and your, way of life. His production efforts have filled the grain bins but not his pocketbook. These production efforts threaten our soil and water resources. Increased use of the land for crop production has been at the expense of land cover that supports wildlife habitat and other resources enjoyed by society at large. This paper will examine the economic conditions of the farm business to see how it may be possible to "strengthen private land management." The State of Colorado will be used as an example of the economic process at play in today's agricultural society.

Changing Times

Today's North American farmer is part of an amazing agricultural achievement.

But it takes more than past accomplishments to survive in today's agriculture. Agriculture in the United States is changing dramatically and rapidly. The substitution of capital inputs for labor and land has been a prominent feature of this change. More costly, larger equipment replaces labor, for instance, and greater capital inputs increase productivity on the same acres. This is vertical integration. It is costly in today's economy. Forces such as inflation, exports, new technologies, non-farm employment opportunities, availability of credit, agriculture support programs, and tax rule changes profoundly affect the way United States agriculture is now organized and managed. The success or failure of a farm or ranch business now depends as much on the operator's skill in sound decision making as on his ability to achieve high productivity of crops and livestock.

The farm manager is a businessman and wants to determine his return to the land, labor, management and capital employed in the business. The farm manager is a family man interested in providing adequate income for his family as well as comparing his income with those employing similar skills and having like resources and enterprises. Business management by objectives improves techniques of the farm and ranch manager's decision-making process. Improving the decision-making process aids managers in becoming more successful, achieving greater profits, and providing improved family living.

Farm businesses have three primary objectives: profitability, liquidity, and solvency. These objectives form the framework to develop and improve managerial skills and the decision-making process. It is still important to understand manager's needs, wants, goals, desires and management traits. Personal satisfaction must be achieved for the manager—the husband-wife team. They feel value in self when they can achieve the objectives of increased income, lower costs, improved family living and a great sense of accomplishment. However, to achieve these goals, they must improve their knowledge of economic principles and the decision-making process.

Indeed, if one desires to "strengthen private land management" with the context of improving and conserving our nation's soil, water and wildlife resources, then these primary objectives affecting North American agriculture must be seriously considered.

Colorado's Agricultural Picture

Agriculture is the second largest industry in the state of Colorado. Sales of agricultural commodities add more than $3 billion annually to the economy. Business activity multipliers applied to various kinds of agricultural production average about 3.0 which means that agriculture's contribution to the state's economy is around $9 billion a year.

Colorado ranks 15th in the nation in agricultural sales. It is outranked in the West only by California, the nation's largest agricultural producer. As an industry, agriculture is second only to manufacturing, which adds $5.3 billion to the economy. Other major industries are construction, $2.5 billion; mining, $1.3 billion; and tourism, about $1 billion.

Total cash receipts from Colorado agriculture in 1979 were $3.1 billion. Total realized gross farm income was $3,321 million. Total farm production expenses were $2,698 million. This left a realized net income of $623 million.

The $623 million in realized net farm income in Colorado is up sharply from 1978's $275 million. However, in terms of buying power, net farm income peaked in 1974. When translated into uninflated dollars, the 1979 net income figure is actually 24 percent less than in 1974.

The 1980 projections warn of the challenge ahead for the future of agriculture in Colorado. Economists have predicted net farm income will plummet in 1980 to an estimated net income figure of $400 million.

The sale of Colorado farm and ranch products will add a record $3.53 billion to the state's economy in 1981, forecasters predict, but net income to farm families will drop from 1980 levels. The cost of doing business on Colorado's farms and ranches will continue to climb in 1981, denting net profits by 11 percent. The cost of fertilizer, fuel, and electricity each jumped 25 percent in 1980, and these costs are expected to rise another 10 to 20 percent in 1981. Interest charges are expected to cut into farm profits by about 10 percent in 1981. These continually escalating costs of production will reduce 1981 net income. This creates even more difficulty in obtaining a fair return on investment, as well as a return for labor and management. This situation causes even greater economic problems for you and the farmer-rancher if we are to "strengthen private land management."

What is Management?

These facts point to why farm and ranch management is so critical to the success of each individual farm and ranch family. As costs go up, better management is needed on every farm and ranch. The farmers who have succeeded over the past 15 years have not only been good producers—they also have been good managers.

What is management? It could be said it is the allocation of business resources, like capital, labor, land, fertilizer and equipment, to get maximum return. Or, more simply stated, it is using what you have to get what you want.

Management can be broken into four basic categories: resource management, capital management, labor management and market management. The big job is the allocation of resources. All farms have limited resources, regardless of size, and all have more things to do than to do with. Resource scarcity means it will cost something.

Management is nothing more than maximizing the income from each available resource. No one management plan fits all situations. Farms and ranches with the same resources might allocate them differently due to different goals. Each manager reacts to uncertainties in different ways, depending upon his background, knowledge and beliefs. The manager cannot survive in an agricultural business if he does not plan to achieve the maximum return for each unit of input. Diminishing returns for added units of input will force the manager and his family out of business.

Most of all, management is taking risks. Profits are the rewards for doing it right, and going out of business is the result of doing it wrong. Management is deciding to act or not to act.

The assessment and understanding of the management concepts along with knowing the manager's goals is perhaps the key to those who have interests in the conservation aspect of the land base controlled by the private sector. With this understanding of the farmer's need to allocate his precious resources, the options for land, water and wildlife conservation can be objectively analyzed. This must be our goal if we are to "strengthen private land management."

Colorado's Future

The future of our productive, but diminishing, farmland and rangeland is one of the questions that we must address. The future isn't something we inherit, but something we create. Rural Colorado is a key element in the state's economy, and the facts of life are stark. From 1967 to 1977, 400,000 acres of Colorado farmland were converted to urban use; we are expected to lose another 345,000 acres by the year 2000—19 percent of the prime agricultural turf in the state. Meanwhile, even though Colorado is one of the fastest growing states in the nation, a majority of Colorado's counties experienced a *decrease* in population over the last decade. The Ogallala aquifer in eastern Colorado is rapidly depleting. A tractor costing $2,000 in 1952 now costs $15,000 to replace. Yet wheat sold for $2.10 per bushel in 1952 and only $2.55 in January of 1979.

The problems of rural Colorado are complex. We must intensify rural development efforts to reverse the trend of people and capital away from rural Colorado. We must make it financially feasible for the farmer to keep critical agricultural lands in production. We must provide increased access and convenience for residents of rural areas through decentralized government services, expanded rural health services, and aggressive Main Street development. The quality of life in Colorado should not depend on one's proximity to a large city.

Water is a critical resource to the farmer and rancher as well as the urban and industry sectors. Competition for water is acute. Colorado is one of very few states into which no water flows; and not much falls here, either. Seventy-three percent of the nation's precipitation falls east of the 100th meridian. Another 14 percent falls in the Pacific Northwest. That leaves only 13 percent of the nation's precipitation falling in the Rocky Mountain West—an area representing 41 percent of our national land mass. The monetary value of some Colorado water has increased more than a thousand times in the past 20 years; other water prices have tripled in less than two years. This represents a capital investment to the private land owner—another resource with a high cost.

It is a fact of the market economy that water gravitates towards money. We must plan for water distribution if we are to preserve agriculture. At the same time we must provide water for an average of seven new people arriving in Colorado every hour and provide for a booming energy industry. We must store water. The debate over the fundamentals of our water law will consume increasing public attention in the next decade as pressure mounts to restrict the transfer from agricultural to municipal or industrial energy use. Water is a key element in developing plans for "strengthening private land management." Besides the conversion of agricultural land to housing areas, two other factors affect agricultural land conversion: land quality and agricultural activity.

One of the most serious threats to agricultural land quality is erosion by wind and water. Agricultural productivity losses due to soil erosion are five times greater than the nationwide losses incurred from urbanization, roads and highways. Colorado loses more than 11 tons of soil per acre of cropland to erosion each year.

Transition

High costs and low prices are a major factor in reducing the level of agricultural activity as costs for farm machinery, fuel, seed, labor and other factors rise higher and faster than the prices for agricultural products.

The average net income of southeast Colorado farm and ranch business records in 1979 was $26,000 on an average investment of $520,000—a 5-percent return on investment. This makes it difficult for a farmer to turn down a lucrative offer from a land developer, even if he would rather farm than do anything else. The cost-price squeeze has put great pressure for conversion even on highly productive, well-managed farms.

We are losing a culture, a way of life as family farmers. We are being financially forced to "give up." There is a rural depression. It is causing a chain reaction of insufficient farm receipts, which show up in our rural communities as a depletion of Main Street business, lowered land values, decreased local taxes, reduced employment opportunities and deteriorating churches and schools. Our rural lending institutions are under heavy stress.

The question arises, "why farm?", when one could put the same money in the bank or in a savings and loan association and realize a higher percentage of return. The farmer-rancher is the only businessman who pays the freight both ways. He buys retail and sells wholesale and has no way of demanding even the cost of production out of his product. We must make it financially feasible for the farmer to keep critical agricultural lands in production. We must see how "strengthening private land management" can be a part of achieving this goal.

I suggest to you, the conservation minded person, that there is a strong relationship between the quality of life that I addressed and the environmental amenities you would seek to emphasize in "strengthening private land management."

The Facts Show the Reality

Business analysis records of farms and ranches in southeast Colorado portray the problems and trends faced by the managers of these businesses. The Southeast Farm Business Association, in cooperation with Colorado State University Cooperative Extension Service, provides farmers and ranchers with business management analysis. The group receives an analysis of their farming operation, help with their farm accounts, income tax planning and assistance and advisory consultation on their farm and ranch problems. It is called Management by Objectives.

The results of the last three years of analyzing these farm businesses are summarized by farming type in Tables 1, 2, and 3. Records have been summarized on these businesses since 1968. The following definitions of business analysis terms will aid in understanding the farm and ranch business analysis figures. *Net farm or ranch income* measures the actual profit or loss for the year. It is the net cash income with inventory adjustments. *Management return* equals net farm income plus interest paid, minus 6 percent on average investment in feeds, non-feeds, livestock, and machinery, minus 5 percent interest on capital in land and improvements, minus wages for operator and unpaid family labor. This measures return to the farm operator for management after deducting a charge for all other resources. *Total gross profits* measures the production per farm. This is a very important

Table 1. Southeast Farm Business Association Trends—dryland.

	1977	1978	1979
Net Income Factors			
Total cash income	$ 84,942	$105,018	$141,041
Total cash expenses	56,051	87,138	103,297
Total depreciation	10,019	11,911	14,659
Inventory change	6,482	25,973	22,141
Net farm income	25,354	31,942	45,226
Capital Management			
Total capital managed	$376,556	$405,321	$458,704
% return, capital, management, and labor	6.73%	7.88%	13.19%
Return to management	7,995	12,102	13,887
Production Factors			
Gross profit (production)	$ 81,328	$ 91,870	$121,821
Man years	1.51	1.51	1.52
Gross profit, per man years	52,669	61,418	82,013
Cropland acres	2,110	2,034	2,125
Gross profit/cropland acre	39	45	57
Efficiency Factors			
Total expenses/cropland acre	$ 26.53	$ 29.47	$ 36.05
Net income/cropland acre	12.02	15.71	21.28
Total expenses/$100 gross profit	68.82	65.23	62.88
Livestock returns/$100 feed fed	138	223	200

Table 2. Southeast Farm Business Association Trends—valley irrigated.

	1977	1978	1979
Net Income Factors			
Total cash income	$113,744	$162,742	$172,563
Total cash expenses	96,722	130,934	147,880
Total depreciation	9,989	10,267	13,276
Inventory change	7,783	30.077	41,676
Net farm income	14,816	51,618	53,082
Capital Management			
Total capital managed	$366,878	$382,327	$461,449
% return, capital, management, and labor	4.04%	16.52%	14.03%
Return to management	(−2,557)	34,305	18,196
Production Factors			
Gross profit (production)	$ 77,424	$119,681	$134,660
Man years	1.60	1.57	1.74
Gross profit, per man years	47,294	74,841	75,215
Cropland acres	566	491	597
Gross profit/cropland acre	137	244	226

Table 2. Continued

Efficiency Factors			
Total expenses/cropland acre	$ 110.62	$ 138.62	$ 136.75
Net income/cropland acre	26.18	105.13	88.99
Total expenses/$100 gross profit	80.86	56.87	60.58
Livestock returns/$100 feed fed	145	204	192

Table 3. Southeast Farm Business Association Trends—dryland-irrigated combined.

	1977	1978	1979
Net Income Factors			
Total cash income	$148,018	$184,693	$218,062
Total cash expenses	107,255	159,705	152,716
Total depreciation	17,144	18,962	21,015
Inventory change	13,902	22,649	24,432
Net farm income	37,521	28,675	69,764
Capital Management			
Total capital managed	$465,373	$586,827	$637,711
% return, capital, management, and labor	8.06%	4.89%	14.17%
Return to management	17,160	11,373	28,401
Production Factors			
Gross profit (production)	$153,486	$167,179	$210,021
Man years	1.76	1.83	1.62
Gross profit, per man years	89,193	83,970	129,022
Cropland acres	1,831	2,065	1,982
Gross profit/cropland acre	84	81	106
Efficiency Factors			
Total expenses/cropland acre	$ 63.34	$ 67.08	$ 70.76
Net income/cropland acre	20.50	13.89	35.19
Total expenses/$100 gross profit	75.55	82.85	66.78
Livestock returns/$100 feed fed	144	197	262

analysis factor as it indicates size and scale of the business. *Production and efficiency factors* measures the decisions to allocate resources of land, labor, and production inputs.

If you were to review this data with a view to investing your assets for maximum financial return, the conclusions might be illuminating. These figures are average and do not indicate the wide range of variation between individual farm businesses. Net farm income is on an inventory base. Therefore, income is not always available for use in cash flow. It may still be in the grain bin, in the hay stack or on the hoof. The returns to investment of a half million dollar business are limited. Ideally, it should cost $60 to produce $100 of gross profits. The average figure looks fair but many individuals are paying over $80 in production costs to produce $100 of gross profits. This does not leave enough profit to create an equitable return to investment.

While the 1979 data indicates some improvement over previous years, the improved return to investment, labor and management has not kept pace with inflation. The cost of operating capital has become a major production input cost. Extreme stress is placed on the cash flow situation when other costs are also rapidly increasing. The low returns to large amounts of capital managed by the family farmer and rancher place a real burden on the business to remain solvent and continue to operate.

The private land owner, the farmer and rancher, is continually faced with low returns for his high input costs. He has been using the production concept of planting "fence row to fence row" to increase production volume which he hopes, when marketed, will pay for the high input costs. This production concept is actually causing diminishing returns per acre even though the operator may see a greater volume of production. This is perhaps the principal economic key to "strengthening private land management." It is the old diminishing marginal returns principle with which every student of economics is acquainted.

Without profit—net income—the farmer and rancher is unable to apply soil and water conservation practices to enhance the per acre return on more productive land and thereby idle marginal acres. He must allocate his capital resources and set priorities. To pay for the high input costs is first priority and this does not leave capital resources available to pay for needed soil and water conservation practices. Practices to consider are: concrete irrigation ditches and pipelines, terraces, grassed waterways, land leveling, windbreaks, and improving mountain meadow production.

A small percentage of farmers and ranchers have had capital available to develop these conservation practices and to gain proven increased per acre returns. Capital investment costs are high but over a period of years income returns can offset the initial costs. Marginal acres which are removed from production can be utilized for wildlife habitat. This can create a better social-economic base in our rural communities. This would be a benefit to each farm and ranch family business. Diverting nonprofitable lands to wildlife habitat would enhance the well being, not only of the farm and ranch family, but of all people.

Summary

You, the conservation minded person, and the farmer have a stake in the economics of operating a farm or ranch as a profitable business venture. There is a strong relationship between the quality of life in rural communities and the environmental amenities you would seek to emphasize in "strengthening private land management."

The family farm is a basic thread in our economy—it must remain, and to do so, there must be an equitable return to the farm and ranch manager and his family.

The American farmer is custodian of vast stretches of our countryside. He loves the land. He knows the secret of its bounty. We all share in this heritage and enjoy the bounty of its fruits.

Management by Objectives, I believe, shows the way to achieve the twin objectives of farm business solvency and conservative land use. Since it is the all important dollar that directs private land management, sound financial management must be a primary key to "strengthening private land management."

Missouri's Landowners: How They Perceive the Importance of Wildlife

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Introduction

Conservationists have long recognized the role of private landowners in providing for wildlife resources and associated public recreation. A wide range of programs have been implemented across the nation encouraging landowners to incorporate wildlife habitat into their land management schemes.

Many of the early wildlife programs on private lands were patterned after the Williamston Plan developed in Michigan (Wight 1933). The major features of early private land programs were control of hunting pressure and harvest, often with provisions for some public use.

As agriculture intensified during the late 1940s, wildlife programs on private lands were directed toward reducing the impact of habitat loss associated with increased emphasis on food and fiber production. Private land-wildlife programs which evolved during the 1950s and 1960s generally included advice to landowners for improving farm conditions for wildlife. Some states also supplied food and cover planting materials, free labor, fertilizer, and fencing to accomplish the necessary improvements. Habitat restoration efforts often were combined with programs administered by federal agencies such as the Cooperative Extension Service, Soil Conservaton Service (SCS), and the Agricultural Stabilization and Conservation Service (ASCS).

Most private land-wildlife programs developed to date have been based upon wildlife resource managers' perceptions of habitat needs or their assessment of the importance of private lands in meeting the demand for wildlife oriented recreation. Few programs considered the management problems facing landowners when prescribing wildlife plans to be incorporated with agricultural practices. Recently, experimental incentive and cost-sharing programs for landowners indicate that wildlife managers are becoming more aware of problems facing landowners and are making efforts to cooperatively improve wildlife habitat on private land without jeopardizing agricultural production. Some of the new programs being examined by wildlife managers, such as conservation tillage, strip cropping, and native grass forage systems, may in fact improve agricultural productivity and wildlife habitat concurrently.

In order to be successful, however, future wildlife management programs on private lands must consider not only agricultural economics and sound land management practices, but also the landowners' attitudes toward wildlife on their farms. Assumptions often have been made concerning the landowners' views about their role in providing wildlife habitat and related recreation, but little factual information is available on the subject.

A study of private landowners and farm operators in Missouri was conducted in 1980 to better understand the perceptions of the agricultural community toward wildlife. Objectives of this study were to determine the importance that landowners and farm operators place on wildlife in their land management, how they perceive winter food and cover quality for wildlife on their land, and their desire for assistance to improve wildlife habitat. The first two objectives are addressed within this paper. Results pertaining to the third objective are reported by Kirby et al. (in press).

Methods

A self-administered, mail-back questionnaire was designed using techniques described by Dillman (1978) and Brown et al. (1978). The Missouri landowner sampling frame was stratified into 123,996 known farm operators and 1,871 landlords who do not farm the land themselves from which a sample of 9,367 farm operators and 918 landlords was selected. During the spring of 1980, each individual was sent a questionnaire and a cover letter explaining the project. Of the 9,834 questionnaires that were delivered, 6,071 (62 percent) were returned after two follow-up mailings. The final number of usable forms was 5,541 (56 percent); 277 were from the landlords and 5,264 from the farm operators. Unless specified otherwise, the results are appropriate for the total sampling frame. No study of nonrespondents was undertaken, so no evaluation of possible nonresponse bias could be offered. The percentages which follow have been adjusted for nonresponse.

Results

The Role of Wildlife-related Recreation

Landowners' participation. Missouri's landowners are active participants in wildlife-related recreation. About 63 percent indicated that they hunt, 64 percent said they fish, and 12 percent indicated they trap. Younger landowners were more likely to hunt, fish, and trap than were older landowners.

These high levels of participation were not unexpected because Missouri landowners could hunt and fish without permits on their farms where they reside. Since the survey, this privilege has been extended to include all lands owned and operated by the Missouri farmer.

Not only were Missouri landowners active participants in wildlife-related recreation, but they made extensive use of their own farmland for these activities. Of the landowners who hunted, 57 percent indicated that they hunted exclusively on their own land, while an additional 35 percent hunted on their own land but not exclusively. Only 8 percent of those who hunted depended entirely on land other than their own for hunting recreation (Table 1). Of those landowners who fished, 49 percent did so only on their farms, 27 percent fished on their farms and other waters, and 24 percent fished exclusively on waters owned by others. Seventy-eight percent of the landowners who trapped participated only on their lands.

Participation by others. An estimated 93 percent of Missouri's land area is in private ownership (Hendrix and Headley 1978). Missouri's landowners, therefore, play a major role in providing approximately one-half million people a place to

Table 1. Landowners' use of private and public land for hunting, fishing, and trapping in Missouri.

	Only his own	Only other private	Only public	Only his own and other private	Only his own and public	Only other private and public	His own, other private and public
Hunt	57.1	4.7	2.2	19.4	3.4	0.9	12.2
Fish	49.2	6.2	13.2	8.9	8.0	4.3	10.2
Trap	77.9	3.9	2.1	10.4	1.3	0.9	4.1

hunt. Thirty percent of the landowners indicated that they allowed the public to hunt on their land with permission, and 59 percent indicated that they allowed only family and friends to hunt.

Surprisingly, of five wildlife-related activities (hunting, fishing, trapping, hiking, and bird watching), hunting was the least restricted, with only 11 percent of the landowners not allowing anyone to hunt on their land. Trapping was the most restricted with 45 percent prohibiting anyone from trapping on their farms. Hiking and bird watching were not permitted by roughly 20 percent of the landowners, and 16 percent allowed no fishing. Of the five activities, landowners were most permissive of public access for bird watching (38 percent) and hiking (35 percent).

Landowners 18-30 years of age were more willing than any other age group to allow public access for the five wildlife-related activities. Landowners residing in urban areas (greater than 20,000) were less likely to allow anyone to enter their land for wildlife-related activities than those living in rural areas and small towns. These two findings are similar to those from landowner studies in Colorado (Guynn 1979) and New York (Brown and Thompson 1976).

The Role of Wildlife in Farm Management

Conservation agencies frequently have been made aware of at least one aspect of wildlife's role in private lands management. Most agencies receive numerous complaints from landowners about damage inflicted by wildlife on their property. Usually, however, agencies receive few other indications of the importance of wildlife to private land managers.

To determine the extent of wildlife damage in Missouri, respondents were asked if they had experienced damage during the past 12 months. If they had damage, they were also asked to indicate its severity and the species involved. Twenty-nine percent indicated that they had incurred some damage. Only 16 percent of those incurring damage, however, reported that it was substantial and unreasonable. The majority (54 percent) of those having damage indicated that the damage was noticeable but acceptable, and 30 percent said that the damage was small and unimportant.

In all, 34 species and groups of species were mentioned as causing some level of damage. The white-tailed deer was cited most frequently (42 percent), followed by raccoon (12 percent), coyote (10 percent), beaver (7 percent), and groundhogs (5 percent). The remaining species were cited less than five percent of the time. Although deer were cited most frequently, only 11 percent of those mentioning deer indicated that their damage was substantial and unreasonable. In contrast, 34 percent of those mentioning coyote said the damage was substantial and unreasonable, as did 18 percent mentioning raccoon.

Feeding of wildlife by private landowners provides another indication of how they view the role of wildlife. Some of the worst winter weather recorded for the Midwest occurred during the winters of 1977-1979. Reports of farmers feeding wildlife were widespread throughout Missouri during this period. Respondents were asked if they had purchased grain or used grain from their own supplies to feed wildlife during this time. Fifty-four percent of the landowners indicated that they had provided grain for wildlife, showing a genuine concern for wildlife populations.

Respondents also were asked to rate their land for providing adequate winter food and cover for wildlife. Ten percent indicated that their land was "excellent," 31 percent "good," 40 percent "fair," 15 percent "poor," and 4 percent were unsure or did not know how their land would rate. In general, landowners believe that wildlife habitat in Missouri is quite good, contrary to observations by wildlife professionals.

Missouri's landowners, like farmers around the world, are in the business of raising agricultural products and not in managing their land strictly for wildlife. Conservationists, however, hope that wildlife plays a role in the management of farmland. Respondents were asked to indicate the importance of each of three factors which could play a role in farm management: income, pleasure of farming, and wildlife/recreation interests. A majority (59 percent) rated income as "extremely important." Fewer (41 percent) said pleasure of farming was "extremely important," and still fewer (20 percent) said wildlife/recreation interests were "extremely important." Of great significance, however, is that 83 percent of Missouri's landowners said that wildlife was at least slightly important in their farm management.

Regional Differences in Wildlife's Importance

The foregoing summary is a statewide generalization of the role that wildlife plays in private land management. However, landowners' perceptions of wildlife's importance differ by regions within Missouri. Following are some of these key differences.

Missouri's total land area is about 44 million acres (17.8 million ha) and lies in the central United States. It is bounded by the Mississippi River on the east, the Great Plains on the north and west, and the southern forests on the south. The state has been divided into eight zoogeographic regions (Figure 1) (Bennitt and Nagel 1931). Farm characteristics within each of the regions are different depending upon soil types, topography, and primary management practices. For example, in those regions north of the Missouri River and in the Mississippi lowlands of southeastern Missouri where the soils are relatively rich and well-drained, more than 49 percent of Missouri's farm operators managed their land principally for crops. Average farm size in these regions was over 300 acres (121 ha) (Figure 1). In the Ozark and western prairie regions, where the soils are relatively thin and poor for crops, more than 55 percent of farm operators managed primarily for livestock. Their farms averaged less than 261 acres (106 ha). In those regions where the majority of the farm operators managed primarily for crops, 49-80

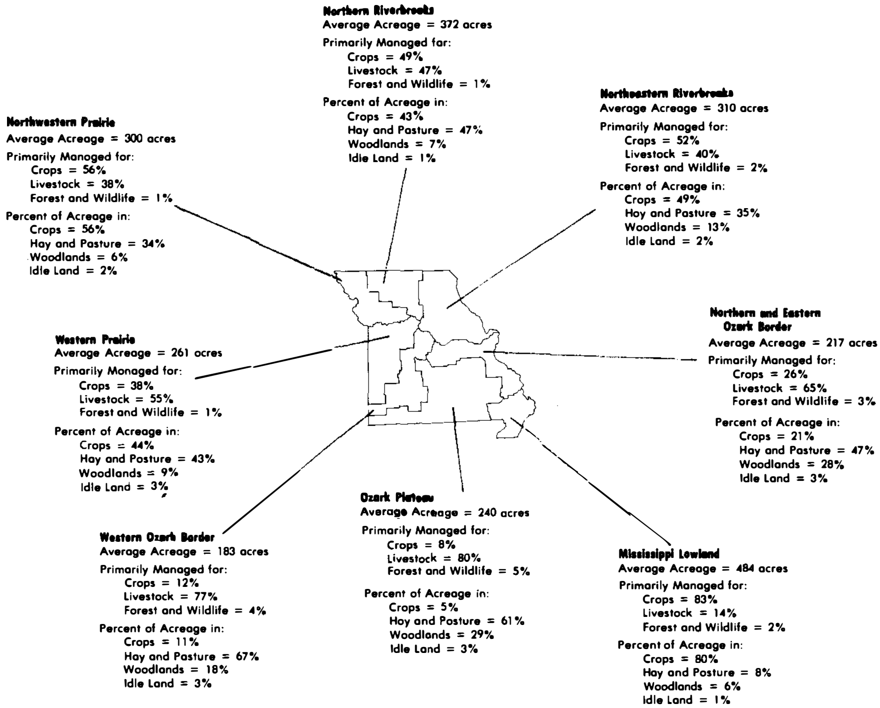

Figure 1. Characteristics of the farm operators' lands in Missouri by zoogeographic regions.

percent of the farm acreage was in corn, soybeans, wheat, or milo and 6-7 percent in woodlands or woodlots. Where the majority of farm operators managed primarily for livestock, 43-61 percent of the farm acreage was in hay and pasture and 9-29 percent in woodlands or woodlots.

Landowners' perceptions of the importance of wildlife seem to vary across primary agricultural practices. Wildlife was at least moderately important in farm management for 60 percent of the landowners who managed primarily for livestock, but only to 53 percent of those who managed primarily for crops. Income was considered extremely important by 53 percent of the landowners managing for livestock and 74 percent of those who managed for crops. Income's importance is evident especially in the Mississippi lowland and northwestern prairie regions where the highest proportion of landowners managed primarily for crops and land values generally are higher. The importance of wildlife within those regions was lower than in other regions.

In Missouri (and probably the rest of the United States) where the soils are deep and fertile, income becomes the private landowner's guiding factor in farm management. In regions where the soils are not as fertile and livestock operations are more prevalent, wildlife interests assume a more important role in the landowner's management decisions.

Discussion

This survey indicated that Missouri landowners perceived wildlife to be important in a number of ways. Most landowners participated in wildlife-related recreation, substantial numbers of them allowed other people to do so on their lands, many voluntarily provided feed for wildlife during harsh winters, and nearly all felt that wild animals play some positive role in the management of their farms.

These results raise the question of why wildlife agencies have such deep concerns with respect to the future of wildlife habitat on private lands. It seems inconsistent that wildlife conservationists and landowners—two groups with so many common wildlife concerns—should ever come into conflict on the basis of wildlife.

The cause for tensions between the two groups is that wildlife is the primary product of agency efforts, while wildlife is a by-product of farm management. Differences of opinion between these groups on the role wildlife should play in farm management are thus inevitable. There are no easy ways to resolve these differences.

The long-time concern of professionals for the role of private lands in wildlife management was evidenced by a presentation on private lands at the Third North American Wildlife Conference nearly half a century ago (Shantz et al. 1938). Interestingly, the same suggestions that emerged then are the best we can offer today—cooperation and communication.

Conservation agencies must take the initiative in cooperating to meet wildlife needs on private lands. Present programs exemplify the success of these efforts. In 1980, for example, the Field Service Section of the Missouri Department of Conservation responded to more than 9,000 requests from landowners seeking food plot and cover materials.

This survey revealed high interest in wildlife, but also provided reminders that some landowners experience property damage from wildlife. We believe that Missouri's landowners generally feel that such damage may be expected when agriculture and wildlife are mixed. However, the Missouri Department of Conservation recognizes that these problems can impose a substantial economic burden on farmers, and offers them assistance and training in wildlife damage control.

A third example of cooperation concerns landowner rights. Government ownership of wildlife is the necessary rule, but agencies have ignored consideration of landowner privileges in return for providing wildlife habitat needs for too long. In 1980, the Department substantially liberalized the rights of Missouri landowners and their families to harvest wildlife on their lands. The response by landowners was understandably appreciative and is likely to facilitate future communication between the agency and landowners.

Communication, the second major suggestion for resolving differences between wildlife conservationists and landowners seems all too obvious, but unfortunately it is exercised all too infrequently, is often incomplete, or is carried out with no thought of compromise by either party. Exchanges of information between agency personnel and landowners can range from a formal presentation by a Conservation Agent before a farm organization to an informal chat over the back fence. Sharing ideas is vitally important in promoting understanding between wildlife conservationists and landowners.

The positive attitude that most landowners hold toward wildlife is extremely encouraging. Through cooperation and communication, the wildlife profession should be able to strengthen private lands management in the 1980s and beyond to the benefit of wildlife and society.

Acknowledgments

We wish to thank Sallee Butler and Alan Crossley for assistance with data coding and analysis, and the Missouri Department of Conservation employees who assisted in the completion of this project. Gratitude is also extended to Don Bay and his staff at the Missouri Crop and Livestock Reporting Service for their help in the preparation of the questionnaire and sampling frames. Appreciation is extended to Lisa Clausen for editing the manuscript. Special appreciation is extended to the Missouri landowners who participated in this study.

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Property Tax Credits to Preserve Wetlands and Native Prairie

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Pre-settlement Minnesota was a place of vast diversity of tallgrass prairies, coniferous forests, hardwood forests, and all of the interfaces where these great ecosystems met. Most of southern, southwestern and western Minnesota was in tallgrass prairie before settlement. Much of the interface areas between the forests and the prairie zones were also covered by prairie grasses (U.S. Department of Agriculture 1974).

Almost all of Minnesota, except for the extreme southeastern fringe along the Mississippi River, was glaciated during the Pleistocene age (Willard 1922). This glaciation left many depressional areas throughout the state and made us the land of 10,000 lakes. Actually, there are 15,291 lakes in the State (Minnesota Department of Conservation 1968), and along with these recognizable lakes, there are vitually millions of potholes, sloughs and marshes (Mann 1955); most of them remnants of glacial activity.

The early settlers who came to Minnesota were primarily farmers, loggers and businessmen who made their livelihood from the land and its products. These settlers found Minnesota a fertile, productive place to work, and work they did. They were, for the most part, northern Europeans with a heavy leaning toward the Swedes and Norwegians—a trait for which Minnesota is well known today. As these settlers went about conquering their new land, they logged the woods, broke the prairies and built their business like there was no end to the work to be done and no end to the resources to be harvested. They were mistaken and, in the face of abundance, acted with extravagance. When the forests were exhausted, the once boom towns of the north became ghost towns (Sakry 1957).

Meanwhile, hard working farmers on the prairies found a rich, fertile soil in which to grow crops and livestock which produced an immense richness upon which communities grew. As they caught up with the work of making homes, breaking the land and establishing businesses, they often were able to improve their agricultural production by draining sloughs and marshes and gaining land which proved, in many cases, to be very fertile. In other cases, drainage efforts didn't pay off, leaving drained marshes, no profits and heartbreak.

Like the loggers of the north, the prairie farmers went about breaking and using the land like there was no end to the vast resources they were converting to their uses. The resulting story of the "dirty thirties" and the need for soil conservation is a very familiar one to everybody here.

Minnesota came out of the depression years into the boom times of the forties with a new mechanization and a new determination for utilizing even more of the land. The descendants of hardy settlers continued their forefathers' work with a new technology. Consequently, they made even more inroads into those natural ecosystems which escaped earlier efforts. Virtually no prairie is unbreakable with the power available now, and almost all water can be drained someplace if the drainers try hard enough, and they're trying harder all the time.

Minnesota went from an abundance of grasslands which covered nearly a third of the state, about 18 million acres (7.3 million ha), down to probably less than 50 thousand acres (20,250 ha) of privately-owned native prairie today (Crete pers. comm., 1980). We went from many millions of acres of wetlands to probably less than 2 million acres (810,000 ha) today. I'm not sure anybody will ever know for sure how many acres we had or exactly how many acres remain, but we do know that our wetland and native prairie acreage today is only a remnant of what once was.

Through a land acquisition program financed by the sale of migratory bird hunting stamps, the U.S. Fish and Wildlife Service has preserved 81 thousand acres (32,805 ha) of wetlands in Minnesota (U.S. Fish and Wildlife Service 1980). The Minnesota Department of Natural Resources owns about 250 thousand acres (101,250 ha) of wetlands for wildlife management purposes. The U.S. Department of Agriculture has about 22 thousand acres (8,910 ha) of Minnesota wetlands enrolled in the Water Bank Program. Additionally, in Minnesota we have a wetland protection law commonly called the Public Waters Law in which the State regulates certain destructive activities in certain wetland basins.

Of our native prairie remnants, The Nature Conservancy has preserved about 9 thousand acres (3,645 ha) through purchase. About 30 thousand more acres (12,150 ha) have been preserved by the state and federal governments through fee acquisition. While this acreage may seem impressive, it is far too little to be a major factor in native prairie preservation.

In spite of efforts to preserve our native prairie and wetlands, the private profit incentives to break out new lands, drain wetlands and bring more land into agricultural production are very much with us. Minnesota's income tax structure encourages investment in land development, and in spite of past cost sharing for drainage and present programs to preserve wetlands, major land use decisions on our farms are not made by the government. They're made by private individuals exercising something very basic to farmers, and that is to do on one's land as one sees fit.

Acquisition of lands by government agencies is only part of what is needed for preservation of natural land features. In Minnesota, and I suspect elsewhere, we also need financial incentives for private landowners to maintain, in private ownership, the natural features we so value—in Minnesota's case, wetlands and native prairie.

In Minnesota, wetlands were taxed at somewhat less than one dollar per acre per year. Native prairie lands are taxed at a rate somewhat higher—as much as three to five dollars per acre per year. A farmer who paid these taxes very often expressed the attitude that, since he is paying taxes on these lands, he should be getting something from them, and from native prairie and wetlands, his monetary returns are usually minimal.

From this position, the 1979 Minnesota legislature acted to eliminate property taxes on qualifying wetlands. Further, the legislature provided a credit to wetland owners if they would agree to preserve their wetlands in a natural state. The legislature granted the wetland tax exemption and credit as a deduction from net taxes due on a given property for every acre of wetland that a landowner agreed to preserve. The length of agreement is one year and agreements are automatically renewable, but may be cancelled by the landowner at any time.

The rate of the wetland tax credit is ¾ of 1 percent of the value of an acre of cropland in a township in which the preserved wetland occurs. For example, if that cropland is valued at $1,000.00 per acre, then ¾ of 1 percent of that value is $7.50. That's the amount that is granted for each acre of wetland preserved through this program and that amount, along with the taxes formerly assigned to wetlands, is deducted from the net property taxes due on each farm for which the agreement is made. If a farmer enrolls 10 acres at $7.50 per acre credit, his net taxes are reduced by $75.00, plus the $10.00 or less that was formerly charged as taxes on his wetlands.

In 1980, the legislature amended the wetland tax credit law to include a property tax exemption and credit for the preservation of native prairie. Native prairie, being a bit more productive, is given, first, an exemption from taxation and, secondly, is granted a credit which is 1.5 percent of the market value of an acre of nearby cropland—exactly double the rate of the wetland tax credit. One major difference in the two programs is that the wetland exemption is granted automatically to all agricultural wetlands. The native prairie tax exemption and credit is granted to qualifying native prairie tracts only upon application by the landowner.

Under both the wetland and prairie tax credits, the landowner simply agrees to maintain those features in their natural state for the coming year. He retains all other rights. For example, he can graze his marshlands or make hay on them, he can graze his native prairie, but not overgraze it. He can make hay on it so long as he doesn't destroy the native prairie character of the lands enrolled in the program. He controls all access and all hunting and trapping rights. His agreement with the county is for one year and is automatically renewable. His land is reviewed annually by a local assessor who monitors compliance with these agreements, as well as other developments which affect the value of a farm.

County assessors in almost all Minnesota counties have adequate records on where wetlands are and how large they are. Wetland and prairie preservation agreements are solicited by the county assessor on forms attached to each landowner's tax statement.

County records are generally adequate to administer the wetland tax credit program, but whether or not a piece of land is truly native prairie is a more technical question. If a landowner thinks his land is native prairie, it has never been plowed, and has not been abused to the point that its native prairie character is diminished, he applies to his county assessor for a property tax exemption and credit for his prairie acreage. The assessor refers the request to the Department of Natural Resources for a determination of the eligibility based on the species of native plants present and their overall general condition. Severely overgrazed native prairie lands do not qualify for the exemption and credit. Through the incentive of the tax credit, landowners are encouraged to use good management to protect the native prairie character of the lands enrolled in the program.

So far, these programs have been on the land for only one year. The records are just now being completed on the sign-ups and the participation levels in each county are just now being determined. We don't know for sure yet what this program will cost, but at the present, it appears that we have a multi-million dollar program, which is somewhat larger than we envisioned when we enacted this legislation .

One of the major obstacles we encountered when we began to discuss exemptions from local property taxes was the very obvious problem that the local units of government would not collect the full tax values in their counties as they had been doing. To offset those losses to the counties, the Minnesota Legislature provided that those deficits would be paid to the counties from the state general revenue fund so that there will be no loss of local revenue from property taxes from the wetland and prairie tax credit programs.

General revenue funds are collected from all taxpayers in the state of Minnesota and therein lies the real importance of our new law. We have stated that wetlands have many functions. They obviously provide habitat for waterfowl production and cover for our native game birds and mammals. Wetlands contribute to ground water recharge. They hold back flood waters and reduce downstream flooding. They trap nutrients and sediments and keep them out of our downstream waters. They add a pleasant diversity to our countryside.

Native prairie holds soil tightly in place to prevent soil erosion and improve downstream water quality. They are specialized plant communities which serve as a base for some wildlife species that have become rare or non-existent in many neighborhoods. The native prairie plants provide a diversity of pleasing vistas not often found in our heavily farmed areas and are storehouses of genetic materials of yet unknown value. Minnesota's remaining native prairie tracts, in short, are unique.

We think all of the benefits that wetlands and native prairie provide are valuable to all of our people. Through our tax credits we have a system in which all of our taxpayers can help to bear the expenses of maintaining wetlands and native prairie. If public interests in privately owned natural resources are to be strengthened, it seems appropriate that the public fulfill an obligation to the private landowner to make it worth his while to provide these public benefits. In Minnesota, we feel that we have found a means to that end in our new wetland and prairie tax credits.

We also feel that Minnesota wetlands provide benefits to people in other states. We think it may be time to look for regional and national support of local property tax incentives for wetland preservation to the extent that those benefits are provided to people outside of a given state to people of the nation at large.

We think it is time we look at national legislation that will create a streamlined efficient way of reimbursing the states and private landowners for wetland preservation incentives administered locally and using existing tax structures to grant property tax relief for wetland preservation. We think we've got a good program going in Minnesota and we are hopeful it will provide lasting protection for wetlands and native prairie which, in turn, are valuable not only to wildlife but for people as well.

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Strategies and Goals for Wildlife Habitat Restoration on Agricultural Lands

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Introduction

The stimulus and data for this paper are the result of the action plan embarked upon by the Association of Midwest Fish and Wildlife Agencies. This collective action by the 14 member states was prompted by the declining farm wildlife habitat base in the Midwest. The administrator representatives of the Association felt that the failing of each state was the inability to develop or maintain that necessary habitat on the land rather than ignorance of the technical aspects of what needed to be done to provide farm wildlife habitat. Years of providing free technical assistance to landowners, the planting of a relatively few farm game habitat areas and waiting for the return of the Soil Bank were not doing the job on a large scale. It was the opinion of the Association that either a major effort must be made to improve Midwestern farm wildlife habitat or else many state fish and wildlife agencies must face the fact that those wildlife species associated with farmland habitat are beyond the management capabilities of these agencies. In this paper, the Midwest is defined as that area of the United States composed of the 14 states of Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. Farm wildlife are those species that have, in the recent past, been associated with the agricultural environment of the Midwest.

To provide a basis for developing future goals and management strategies, documentation of the extent and nature of the problem of farmland wildlife and their habitat was necessary. The Association formed the Farm Wildlife Habitat Council in 1979 and gave this body of state wildlife technicians a series of duties. Among these duties was the charge that each state pick an indicator species that inhabits farmland for which there were readily available population survey data and then determine the relative abundance and distribution of that species within the state for two time periods. The first time period was to be a time in the past when the indicator species was at an acceptable population level, and the second time period should be the most recent year for which data was available. It was assumed that this species would be indicative of what had happened to populations of all species dependent upon farmland habitat.

The Farm Wildlife Habitat Council was further charged with developing a list of specific methods for restoring essential habitat while also considering other potential beneficial effects of the recommended methods such as reduced soil erosion, improved water quality, improved soil productivity, etc. Further, the Council was directed to recommend specific strategies by which the restoration methods could be applied to the land. This list, once developed, was reviewed by member states to determine which methods and strategies were common to all states. Finally, each state was asked to review the general concept of these methods and strategies with farm organizations in each state to determine the degree of support or opposition by these farm organizations for the possible methods and strategies.

Wildlife Populations

Not surprisingly, 12 of the 14 states chose the ring-necked pheasant as the indicator species. Almost all of the data related pheasant population changes that occurred between the late 1950s or early 1960s and the late 1970s. The results of this compilation of pheasant survey data, by state, demonstrated the astounding decline of the pheasant in the Midwest (Table 1). Even though there was some variation in base years used for comparison between states, the percent changes in pheasant populations all indicated declines ranging from a low of 34 percent to a high of 96 percent.

Population changes in cottontail rabbits and bobwhite quail from several states were also used to demonstrate changes in farm wildlife populations (Tables 2 and 3). Trends in numbers of these two species are remarkably similar to those demonstrated by the pheasant. Although no data were compared for a wide variety of other farmland wildlife, it is the general consensus of wildlife managers in the Midwest that most other species of farmland wildlife have experienced population changes not unlike those of the ring-necked pheasant, bobwhite quail, and cottontail rabbit. Nongame wildlife species populations in particular have traditionally not been surveyed to any extent. Yet, a quick comparison of nongame species' diversity and abundance between the intensively-utilized private agricultural lands and a public wildlife management area will give an indirect indication of the changes that have occurred in nongame populations in the last 20 to 30 years.

Table 1. Pheasant population changes in 12 midwestern states.

State	Years of comparison	Percent change
Colorado	1958 – 1978	−70%
Illinois	1957 – 1977	−34%
Indiana	1960 – 1978	−91%
Iowa	1963 – 1978	−41%
	Average 1962 – 1964 vs. 1976 – 1978	−33%
Kansas	1963 – 1978	−67%
	Average 1963 – 1967 vs. 1974 – 1978	−58%
Michigan	1957 – 1978	−62%
Minnesota	1960 – 1979	−86%
Nebraska	Average 1961 – 1965 vs. 1973 – 1978	−44%
North Dakota	1963 – 1978	−85%
Ohio	1960 – 1979	−96%
South Dakota	1960 – 1975	−78%
Wisconsin	1962 – 1978	−40%

Table 2. Cottontail rabbit population changes in four midwestern states.

State	Years of comparison	Percent change
Illinois	1957 - 1977	−66%
Indiana	1960 - 1978	−72%
Iowa	1963 - 1978	−24%
	Average 1963 - 1965 vs. 1976 - 1978	−31%
Missouri	Average 1956 - 1959 vs. 1969 - 1977	−59%

Farmland Habitat

The category of prime farmland denotes the best farmland in the United States. It produces the highest crop yields with the least damage to the soil. In 1977, there were about 346 million acres (140.1 million ha) of prime farmland remaining in the United States. Of this total, approximately 52 percent was located in 13 of the Midwestern states—Kentucky being excluded. The very productivity of Midwestern soils and the agricultural utilization of those productive soils have brought about profound farm wildlife habitat changes. The loss of habitat due to changing land use and agricultural practices is recognized as the major reason for the decline in farm wildlife populations throughout the Midwest. Habitat quality and quantity have declined drastically through the region. Between 1975 and 1977, Illinois experienced a loss of 2.2 million acres (0.9 million ha) of farmland to other uses; but the total acreage in crops increased by 2.22 million acres (0.9 million ha). During this same period, the acres of corn, soybeans, and grain sorghum increased slightly over 7 million acres (2.8 million ha) in Illinois. Edge habitat was lost at the rate of 43 percent per decade in northern Illinois; 26 percent in central Illinois; and 16 percent in southern Illinois. In two study areas in Indiana, 50 percent of the good nesting cover and 71 percent of the prime winter cover were lost between 1971 and 1978. The total land in crops in Indiana increased 11–12 million acres (4.4–4.9 million ha) between 1960 and 1978 with row crop acreage increasing 46 percent. In this same 19 years, small grain, hay, and pasture acreages decreased 54 percent, 33 percent, and 29 percent, respectively. In Iowa between 1963 and 1978, the amount of land devoted to corn and soybeans increased 44 percent while

Table 3. Bobwhite quail population changes in four midwestern states

State	Years of comparison	Percent change
Illinois	1957 - 1977	−54%
Indiana	1960 - 1978	−83%
Iowa	1965 - 1978	− 7%
	Average 1965 - 1967 vs. 1976 - 1978	−17%
Kansas	1963 - 1978	−48%
	Average 1963 - 1967 vs. 1974 - 1978	−52%

land in potential nesting cover (hay, oats, and pasture) declined 44 percent. Kansas demonstrated a significant inverse relationship between intensive farming (crop production index and acres harvested) and pheasant and quail populations. Undisturbed perennial nesting cover declined 67 percent in Minnesota between 1960 and 1979 while the percentage of all perennial nesting cover acres considered to be undisturbed decreased 55 percent in the same 20-year period. A consistent trend toward increased acres of row crops was also noted in Minnesota. Row crop acres in Missouri increased 16 percent between 1960 and 1978, while small grain acres declined 50 percent. Also, Missouri forage composition changed remarkably. In 1960, Korean lespedeza, red clover, timothy, and orchard grass accounted for 88 percent of the forage; but by 1978, this had changed to 85 percent fescue. Nebraska noted a 45 percent decrease in the amount of land devoted to alfalfa, native hay, and pasture between 1955 and 1976. Winter wheat acres dropped 23 percent from 1964 to 1976; and by 1976, small grains other than winter wheat were nearly nonexistent. Land occupied by pasture, hay, and grass-legume crops harvested for seed declined 49 percent, 54 percent, and 85 percent, respectively in Ohio between 1959 and 1974. Row crop acres increased 55 percent from 1960 to 1978. Wisconsin found that land devoted to row crops increased 43 percent while small grain acres dropped 49 percent and hay land remained unchanged between 1962 and 1978.

In general, the indicators of farmland wildlife habitat change are increased urbanization of agricultural land; increased farm size; increased total acres in crops; significantly greater acres devoted to row crops; significantly decreased acres devoted to small grains, hay (wild and tame), and pasture; larger fields; and the loss of edge, fence rows, old farmsteads, wetlands, and idle lands. There has been a major shift from diversified farms with good interspersion of a variety of cover types to more simplistic agricultural landscapes dominated by one or two row crops. This has resulted in a reduced number and diversity of wildlife species in the farmlands.

Strategies and Goals

The problem is massive and well documented. Solutions unfortunately are more difficult to implement than the problem is to identify. Basic to the implementation of any strategy for wildlife habitat restoration is the recognition that national agricultural policy is the primary influence on agricultural land use and therefore on farmland wildlife habitat. However, national agricultural policy and the specific methods utilized to carry on that policy must be acceptable to the agricultural community. In the past, national agricultural policy has been primarily price and production oriented with great periodic changes which have prevented such a policy from being based on conservation of the soil, water, and wildlife. Such a policy brought about average erosion rates in 1977 of 9.9 tons of soil per acre on Iowa cropland, 6.7 tons per acre in Illinois, and 10.9 tons per acre in Missouri. Fish and wildlife agencies in the Midwest are prepared to collectively and individually propose program changes that would help conserve soil resources while benefiting wildlife resources. The following list of program changes were identified by the Farm Wildlife Habitat Council:

1. No ASCS cost-share benefits should be available to any landowner who converts Class V, VI, VII, or VIII lands from permanent cover to row crop or small grain production. Such lands should remain in grassland or timber cover for which they are best suited. It may seem incongruous to prevent application of federal crop-sharing funds to control erosion on lands which obviously need them. However, until such limitations are imposed, landowners will continue to convert such lands into production, as they did extensively in 1973 and 1974. Farmers were faced with two incentives to do so; first, they heeded the call for "fence row to fence row production"; secondly, they had experienced high prices and high yields and needed to reinvest considerable sums of money into "land improvement" or other tax deductible activities. The result in the Midwest was extensive conversion of permanent wildlife habitats into marginal crop-producing land.
2. Higher ASCS cost-share rates should be made available for conversion of marginal cropland to permanent cover involving native grasses rather than cool-season grasses. Native grasses, while taking a little more care and time to establish, provide excellent erosion control with signifcantly lower cost and energy utilization. Fertilization requirements of cool-season grasses result in unnecessary use of limited petroleum supplies. The long-term benefits of native grasses as compared to cool-season grasses are significant.
3. Higher ASCS cost-share rates should be employed to encourage greater use of legume crops (where soil moisture is sufficient) in rotation programs to (1) break down a developing pattern of monoculture on some lands, (2) improve soil organic matter on a rotational basis, and (3) reduce erosion on an increased acreage of land. Cost-sharing should be applicable only where the legume crop is permitted to mature into the second growing season to provide the necessary organic matter and nitrogen fixation. A provision permitting a single cutting between July 15 and August 15 could be incorporated to provide income to help offset costs while meeting the objectives for soil improvement plus providing secure nesting cover for certain wildlife species.
4. Tax structures should be modified to permit conversion from irrigation back to dry-land farming even before the irrigation equipment is normally depreciated. Dry-land farming is frequently more cost effective; and while it is recognized that food supplies on a worldwide basis are critical, energy resources and in some areas the water resources are even more finite. Efforts must be made to encourage greater conservation of these. Dry-land farming is generally less intensive than irrigated activities and, therefore, has less negative impacts on wildlife.
5. The concept of higher ASCS cost-share rates being available to landowners who give consideration to wildlife resources by virtue of devoting a minimum percentage of their cropped acreage to permanent cover capable of supporting wildlife, has merit. The percentage rate would not have to be very high; four to five percent conversion of cropable land back to permanent undisturbed cover could devote millions of acres to land uses needed to conserve topsoil and wildlife.
6. Some provision needs to be made in tax incentives or ASCS cost-share rates to discourage fall plowing for spring-planted row crops. Fall plowing is a major factor in wildlife losses in portions of the Midwest—notably Ohio, Indiana, and

Illinois. This activity is becoming increasingly popular in the entire Midwest. It is recognized that fall plowing may permit earlier field entry the following spring. Some studies show increased returns from fall-plowed fields as compared to spring plowing on certain soils. Fall plowing, however, always increases the risk of accelerated erosion of topsoil. In addition, the crop residues are no longer available for wildlife food and cover at a very critical time of the year.

7. Whenever set-aside programs become a part of national agricultural policy in the future, basic fundamental changes need to be imposed. Set-aside programs are periodically developed to reduce production of wheat, feed grain, and occasionally other commodities. The past provisions usually call for a "no weeds" situation. The general result is that landowners are unwilling to plant temporary cover crops. Instead, they periodically till the ground keeping it bare of weeds, exposing it needlessly to increased wind and water erosion, waste petroleum fuels which are in limited supply, and leave the land a virtual biological desert in regard to wildlife. Elimination of the "no weeds" policy, or provisions for payment to establish the needed cover crop, is essential to conserve soil, energy, and wildlife.
8. Conversion of prime farmland to other uses is of major concern across the country. Tax advantages should be made to landowners who decree that their land, through legal restrictions in the deed, shall remain in agricultural production for specific periods of time. Such a provision should have a guaranteed scale for variable periods of preservation of the land as viable farmland. The data presented in this report indicate intensification of agricultural practices has negative impacts on wildlife populations. However, conversion of land to urban uses has even a greater and irretrievable impact on wildlife resources.

In summary, national agricultural policy, in terms of changing ASCS cost-share concepts and specific tax benefits, can be achieved in a manner which will conserve soil, energy, and wildlife resources on a state and national scale. The needed wildlife habitat could be realized through a federal farm program which effectively conserves topsoil and soil productivity.

Specific strategies were reviewed in the form of general concepts by farm organizations in each of the states with the following results:

Supported or Not Opposed:

1. Increased use of conservation tillage.
2. Increased research and teaching of environmentally-sound farming practices by agricultural extension agencies.
3. Earmarking a percent of Federal Agricultural Conservation Program Funds for wildlife conservation practices if the funds were in addition to current funds.
4. Voluntary participation in cropping only fields in which soil losses can be kept below permissible limits. Economic incentives would be necessary to achieve participation.
5. Provide income and/or property tax advantages to landowners providing wildlife habitat.
6. Incentives to landowners to provide wildlife food and cover on marginal agricultural lands if the habitat development did not preclude future cropping.

7. Encourage the establishment of field windbreaks, field borders, and farmstead shelterbelts.
8. Develop funding sources such as hunter-purchased habitat stamps for leasing, purchasing, or developing wildlife habitat.

Opposed or Not Supported:

1. Reduced farm loan interest rates for farms meeting minimum wildlife habitat criteria.
2. Increased crop support payments for farms meeting minimum wildlife habitat criteria and minimum soil loss standards.
3. Required cover crops on all lands set aside under federal cropland retirement programs.

In general, there is support in the agricultural community for agricultural practices that reduce soil erosion if economic incentives by direct payments, tax advantages, or other methods accrue to the private landowner. These practices would also benefit farmland wildlife. Only by taking an active role in joining with farm organizations, soil conservation districts, and other organizations with similar goals can we hope to establish the above-mentioned strategies and others not yet thought of that will conserve soil and wildlife. Therefore, the fish and wildlife community must promote these beneficial practices with Congress and the Department of Agriculture if wildlife habitat is to be restored on agricultural lands. Fish and wildlife agencies, professional associations, and conservation groups must stop talking to one another and start lobbying the people who cast the votes and develop the implementation policies. The Association of Midwest Fish and Wildlife Agencies and its member states plan to follow this route of political involvement to attempt to implement the strategies identified and obtain partially the goal of restoring farmland wildlife habitat.

Acknowledgements

The Farm Wildlife Habitat Council of the Association of Midwest Fish and Wildlife Agencies provided the data for this paper.

USDA Goals for Strengthening Private Land Management in the 1980s

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The pattern for soil and water conservation programs on the more than 1.3 billion acres (526.5 million ha) of private lands of the United States was established in the Dust Bowl and Depression years of the 1930s. While new programs have been added and several programs modified, the basic approach has not changed significantly. What is termed loosely as "soil and water conservation" continues to be a complex mixture of federal, state, and local activities.

The lion's share of public funding for these activities has come from the federal government. The United States Department of Agriculture also has provided most of the technical assistance in planning and applying conservation measures. Much of the soil and water conservation research also has been federally funded, as has much of the cost of the National Cooperative Soil Survey. USDA agencies today administer more than 30 programs covering all aspects of soil and water conservation on private lands.

States also play a growing role in conservation activities. There are state soil conservation agencies in all 50 states, Puerto Rico, and the Virgin Islands. There also are state experiment stations that conduct their own conservation research, often in cooperation with federal scientists and facilities. Several states also provide cost-sharing for conservation work, and most have an impact on conservation activities through various water quality laws.

At the local level, there are 2,950 conservation districts, created under state law, that set soil and water conservation goals and priorities; and in every rural county, conservation cost-sharing is administered by farmer-elected committees established under the Soil Conservation and Domestic Allotment Act.

Private Land Ownership

The total land area of the United States is 2.4 billion acres (956 million ha). About 41 percent of this total is owned by the federal government, by state and local governments, or by Indian tribes. The remaining 59 percent of the land is in private hands. Most of it is owned by individuals, partners, or corporations engaged in farming, ranching, and forestry. Considering our total population, their numbers are not very large. The rural private land of the United States is mostly farms and ranches, which are managed by some 2.5 million people out of a total 1980 population of 225 million.

These private owners are the custodians of the soil that comprises the first few feet of their land. They are custodians of the rocks, water and minerals that lie beneath the soil; of the trees and other vegetation that grow on the land; of the water that runs over or through the land; and of the wild creatures that live there. The decisions that these private owners make about the use of their land and how to manage it have enormous consequences for the rest of us, who depend on them for a continuing supply of food, fiber, timber, and minerals, as well as for much of our environmental quality. The user decisions, of course, are largely dictated by economics, which in turn are an expression of the sum total of demands by the entire population for goods produced from the land base.

This system of private ownership, responsive to economic demands, has certainly delivered the goods. It is a commonplace to observe that the agricultural output of the United States is one of the wonders of the modern world, but it is true nevertheless. Our agriculture, by the standards of most other nations, is free and unfettered. It is also fast-moving and dynamic. Between 1958 and 1977, cropland acreage fell 8 percent, but we produced more food and fiber than ever. Our farmers continuously try out new crops, new machinery, new techniques. There has not been a group of agricultural producers in the history of the world so little wedded to the traditions of the past. American agriculture today is as bold and innovative as the computer industry or space program.

Agriculture in the United States is characterized not only by change but also by variety and complexity. We grow many different crops, in many climatic zones, on thousands of different soils, with many different farming systems. We grow citrus in semi-tropical areas; we grow wheat where temperatures reach 50 degrees below zero (−46° C) in the winter. We engage in dryland farming and several different kinds of irrigated farming. We grow scores of specialty crops, while supplying some 60 percent of the grain delivered to export markets of the world. The size of our farm production units ranges from 10-acre (4 ha) tobacco farms in Maryland to southwestern cattle ranches measured in hundreds of square miles.

Rural land use is changing along with farming methods. These changes occur largely as a result of economic decisions. Between 1967 and 1975, millions of acres went from crops to pasture, and millions more from pasture to crops. Trees were felled on 11 million acres (4.4 million ha) to make way for cropland, while 8 million acres (3.2 million ha) of former cropland reverted to forest. These shifts continue, year after year.

It is in response to this variety and continuous change in American agriculture that complex programs of conservation assistance have evolved at all levels of government. Only flexible, economically feasible, and voluntary programs, with goals set locally, can respond adequately to the needs of our fast-changing farming, ranching, and forestry.

Conservation Policy Aims

It is a continuing objective of the Soil Conservation Service and other USDA agencies to help strengthen resource management on the privately owned land of the United States through the encouragement of voluntarily adopted conservation activities. This encouragement takes many forms: the furnishing of technical information, like the soil survey, on which to base sound land use decisions; the provision of on-site technical assistance by Soil Conservation Service (SCS) professionals and state-employed extension workers; continuing soil and water conservation research; and conservation cost-sharing and other financial incentives. In addition, there are a growing number of laws and regulations, federal, state, and local, which affect soil and water management on private lands. Finally, there is the power of example and persuasion on the part of farmers and ranchers whose success in conservation planning is often the most effective encouragement of all.

Most of these approaches will probably be continued in one form or another. Studies carried out under the Soil and Water Resources Conservation Act (RCA) suggest, however, that changes and improvements can be made that will make these approaches more effective—including more *cost*-effective. But workable ideas for change do not emerge easily. During 3 years of RCA studies, we have tried to estimate the impact on our soil and water resources of several different "scenarios" or forecasts of future demands and developments. We have tried to answer many difficult questions about that uncertain future, often with the aid of computer models. How can we expand our agricultural exports without degrading the soil that makes those exports possible? Can we increase irrigation efficiency to a point where we can stop "mining" our ground-water resources? How can we slow down the loss of our best farmland to nonfarm uses? What can be done about the continuing loss of wetlands and fish and wildlife habitat?

And there are more profound questions. How, for example, do we protect the individual's right to make decisions about his or her private property while protecting the right of future Americans to inherit a productive resource base and healthy environment?

Answers to such questions are often incomplete and unsatisfactory. But we believe we have come up with a few practical approaches. The RCA findings have been made available to the new Administration, and the Secretary's top staff is reviewing them. Several RCA approaches are already embodied in House and Senate bills, along with other new proposals for improving resource management on private lands. These bills and others will be the subject of hearings this year and next.

But even while the Administration is reviewing the RCA recommendations, it is already making clear in public statements that it prefers certain directions to others in pursuing resource management on private lands. The Administration is firmly opposed, for example, to a federally imposed mandatory approach to soil and water conservation. It shares this view with a majority of private landowners. They are convinced that in a country with an agriculture as large and diverse as ours, federal law requiring conservation practices to be mandatory would be counter-productive and a nightmare to draft, administer, and enforce.

There is also widespread opposition to suggestions for compulsory cross-compliance. This Administration does not want to deny farmers and ranchers the benefits of some USDA programs by forcing them to comply with others. But glaring inconsistencies between programs need to be cleared up.

Secretary Block has said that while he considers both soil erosion and the loss of prime farmland as extremely serious, he does not believe that all the solutions to these problems should come from the federal government.

At a press conference after becoming Secretary, he said he believed in encouraging states and local units of government to take more conservation leadership, because they are closer to the people. We can assume that this point of view will be reflected in specific recommendations on resource management.

Major Resource Problems

The more important soil, water, and related resource challenges facing the nation, as defined through the RCA studies are:

1. Continuing pressure for increased production on available private land resources, resulting from increasing domestic and foreign consumption of United States agricultural commodities.
2. Sheet and rill erosion on 94 million acres (38 million ha) of existing cropland at a rate that reduces soil productivity. Other forms of erosion from the action of water and wind also are serious in many localities.
3. Upstream flood damages to farmland and to rural communities.
4. Conversion of agricultural land, including some of our best farmland, to nonfarm uses.
5. Water pollution from sediment—also a product of soil erosion—and from chemicals linked to the sediment.
6. Sharp increases in the cost of producing food and fiber, caused in part by a combination of soil erosion, farmland conversion, and upstream flood damage.
7. Depletion of some ground-water supplies, inefficient irrigation, and increasing competition for surface water supplies.
8. A continuing loss of wetlands and other wildlife habitat.

RCA studies included, but were not limited to, an examination of these problems and of alternative courses of action for dealing with them.

As we look down the road at the rest of the 1980s, we note first that this Administration is committed to an expansion of our agricultural exports. Secretary Block has spoken of his "absolute conviction that what we can do best for all people of this nation is to keep agriculture productive, exporting, strong, and prosperous."

This year USDA projects a record $47 billion in agricultural exports, 17.5 percent above last year's $40 billion level. With agricultural imports to this country forecast at $18 billion, American agricultural exports will enable us to achieve an all-time high of $29 billion on the plus side of our foreign agricultural trade.

The Secretary has also said that "with increasing farm exports, greater world demand, and a stronger national economy, we'll need to produce more in this decade." He is relying on agricultural researchers to help producers come up with part of this higher production, but he has also stated that we must take firm action to reduce erosion and to keep good farmland in farming.

Threat of Soil Erosion

Soil erosion is going to be one of the most significant limiting factors on future production unless we can do a better job than we are doing today in bringing it under control. Erosion from wind and water has been a serious problem in the United States for many years, and it is most critical today in areas of greatest farm productivity.

Soil erosion is an unmitigated evil. It robs land of productivity. It pollutes water. It degrades the environment for fish and wildlife. It destroys crops. It also pollutes the air, contributing to accidents and allergies. There is nothing good to be said for soil erosion.

New soil is continuously forming, but it is forming at a very slow rate. Most cropland soils, however, can bear annual losses of about 5 tons per acre (11 t/ha) and be replenished through natural processes and good management, with no permanent damage to the resource base. If losses exceed this level, however, the topsoil will get thinner and thinner, until it is gone. At that point, crop yields generally fall off sharply and the topsoil can be considered gone for good, at least as man measures time. The damage is permanent and irreversible.

This has already occurred in many parts of the United States; the topsoil was already gone in many sections of the Southeast when the Soil Conservation Service was established. Unfortunately, there are many places in the country today where average annual losses from sheet and rill erosion far exceed the permissible limit of 5 tons per acre. One is Aroostook County, Maine, an important potato-growing area. Its farms suffer annual losses of as much as 100 tons of soil per acre (224 t/ha). Another is the Pacific Northwest, in the wheat-growing region known as the Palouse. There is also continuing severe erosion in the Corn Belt, the Mississippi Delta, and in west Tennessee.

Average annual losses from sheet and rill erosion in 21 west Tennessee counties are among the highest in the nation—30 to 40 tons per acre (67 to 90 t/ha). Some unprotected farms are losing as much as 150 tons per acre (336 t/ha) of soil per year. Rates like these are more than serious; they are catastrophic.

West Tennessee farmers, their state and local agencies, and USDA and the Tennessee Valley Authority are well aware of the situation and are taking concerted action to correct it. But even if these combined efforts are successful, irreversible topsoil losses in a rich farming belt already have taken place.

High erosion rates have not always plagued farms in west Tennessee. They began a few years ago, when farmers switched from pasture, which had held much of the soil in place, to soybeans, a row crop that doesn't produce much residue to protect the soil. The reason for the change, like most changes in agriculture, was economic—a growing market for soybeans overseas.

We have learned that with practically every change in agriculture come new conservation challenges, and Tennessee farmers are learning how to grow their soybeans with farming systems that protect the soil. But it has taken precious time to focus on the problem; it has taken more time to learn what to do about it, and it will take time and money to apply the necessary conservation measures. But the job is going to get done, and many local farmers and conservation professionals are leading the way in showing other local people how to do it.

Would a compulsory soil conservation law have prevented the west Tennessee experience? It is doubtful. It is impossible to legislate against change, even if such a course were desirable. Would a mandatory conservation law hasten the application of needed conservation work? That is also doubtful. American farmers, once they have understood the need for conservation practices and can find the financing to apply them, have generally moved quickly to protect their resources. After all, they have an even bigger stake than the rest of us in keeping their soil—and their property values—intact.

Prime Farmland Losses

Soil erosion is not the only force that is diminishing our finite supply of good farmland. Also of serious concern is the apparently steady loss of some of our finest farmland to nonfarm purposes. These purposes include urban expansion, highways, airports, and lakes and reservoirs. We are also losing farmland to a growing number of rural homesteaders.

Between 1967 and 1975, the permanent conversion from cropland to nonfarm uses averaged 683,000 acres (276,000 ha) per year. Conversion from range and pasture averaged 540,000 acres (219,000 ha) annually, and conversion of nonfederal forest land averaged 822,000 acres (333,000 ha) per year. Much of the land converted was flooded intentionally or paved over and is a permanent loss to agriculture. What is more ominous, about one-third of the land so lost was prime farmland—the level, well drained land that produces the highest crop yields with the least damage to the soil. Unfortunately, such land is just as attractive to developers and builders as it is to farmers, and builders are willing to pay a high price for land that is relatively inexpensive to develop.

The recently completed National Agricultural Lands Study projects that, if current rates continue, Florida will lose nearly all its prime farmland by the turn of the century. For the country as a whole, the remaining national supply of 345 million acres (140 million ha) of prime farmland will be reduced each year unless steps are taken to halt the trend.

When prime farmland is lost to agriculture, farmers drain wetlands or use marginal lands to grow their crops. Marginal land is not only less productive, but it is usually subject to greater erosion hazards; it is usually more sloping and is therefore harder to protect than prime land. Also, when prime farmland is urbanized, much more is lost to the nation than the capacity of the land to grow agricultural products. Because soil that is covered with concrete cannot absorb water from rainfall, erosion and flood hazards increase. Wildlife are forced to look elsewhere for habitat: paved-over land is as dead as the moon.

In a recent talk to the National Agricultural Lands Conference in Chicago, Secretary Block observed that Illinois provides more than 10 percent of the nation's food supply and more than 17 percent of its farm exports. But Illinois, he added, is losing each year about 7 tons of soil per acre (16 t/ha) of cropland to erosion and the equivalent of 373 average-size farms to nonfarm conversion.

"It becomes apparent," he said, "that the increasing pressure on our best land and our decreasing ability to produce from prime land are pulling against each other."

Calling farmland conversion "a potential crisis on several counts," Secretary Block said that "to meet projected demands for the next 20 years, most of the nation's cropland base would have to be in cultivation. This would mean major shifts in the U.S. agricultural system: taking land away from forage and grazing uses, farming poor quality land that is costly to cultivate and subject to erosion and environmental problems, and resulting higher food prices. The chain of problems would be lengthy and expensive."

Secretary Block's commitment to reducing this relentless loss of farmland has gone beyond supportive statements. While Commissioner of Agriculture in Illinois, he helped put through the Agricultural Areas Act. The purpose of that new law is to protect Illinois farmland from development and from state and local pressure to shift farmland to other uses.

Secretary Block has called for a national policy for protecting good agricultural land, saying that "in this time of severe fiscal restraint, I support the (National

Agricultural Lands) study's recommendation that state and local governments take the lead and federal agencies lend support."

Many states today are making some attempt to protect farmlands from encroachment, but so far only a handful have adopted meaningful controls on development. A few approaches, like purchasing redevelopment rights from farmers, have proved too costly for local taxpayers to continue to support them. There is some experimentation with tax incentives; in Wisconsin, for instance, farmers who agree not to develop their land for nonagricultural uses receive significant tax breaks. We will be watching each state experiment with interest. Meanwhile, USDA agencies have a meaningful role to play in helping to discourage other federal agencies from using prime farmland for federally aided projects.

To help local communities identify good farmland—a prerequisite to protecting it—the Soil Conservation Service is publishing county maps showing the location of important farmlands, including prime and unique farmlands. Publication of these maps conforms with our objective of making useful data available to state and local governments to enable them to make rational land use decisions.

Upstream Flood Damages

About 175 million acres (70 million ha) of nonfederal rural land in the United States are classified as flood prone. (A flood-prone area is one adjoining a river, stream, or lake, where there is a 1-percent chance of flooding in any given year.)

About 48 million acres (19 million ha) of flood-prone land are cropland; 106 million acres (43 million ha) are pasture, range, or forest; and 21 million acres (8.5 million ha) are classified as other rural land. In addition, 21,000 communities are subject to flooding, including 6,000 towns or cities with populations exceeding 2,500.

The cost of upstream flood damages is expected to increase about 35 percent during the next 20 years, partly as a result of construction that alters patterns of water absorption and runoff.

Flooding is a threat to human life and health and a destroyer of property. And, like erosion and urbanization, flooding reduces the total production on existing farmland. Because flood plain soils tend to be among the most fertile, the crop and pasture production lost as a result of flooding is high in proportion to the area planted.

For many communities, one answer to upstream flood damages is the development of small watershed projects under Public Law 83-566. These projects, which are limited by law to watersheds of 250,000 acres (101,000 ha) or less, employ a combination of conservation land treatment, other nonstructural means, and floodwater-retarding structures to lessen the effects of unusually heavy rainstorms.

Another answer to reducing upstream flooding, particularly in built-up areas, lies in local ordinances and better city engineering for improved stormwater management. In Independence, Missouri, for example, there was a disastrous flash flood a few years ago. Now, however, new approaches there have demonstrated that new suburban construction does not necessarily have to increase the incidence of floods. Stormwater is being stored or diverted in a variety of ingenious ways to offset the increased local runoff from roofs and paved areas.

One of the primary goals that has emerged from the RCA process is to focus on upstream flood prevention activities in areas where losses to property and crops are highest. In these areas social and environmental values would be emphasized and nonstructural measures would be used wherever feasible. To prevent upstream flooding, more research will be required on improved water management systems that are compatible with crop and grassland production goals.

Habitat Goals for Fish and Wildlife

RCA activities also have recognized that the private landowner has a major effect on the health and size of wildlife populations, in that use and management of soil and water heavily influence the quality of habitat. Future demand for cultivated crops, forest products, and red meat will be met only with great effort, intensive land use, and constant attention to the land. For wildlife habitat to continue to occupy a favorable position in this future, we must temper our use of the land with sound soil and water conservation practices.

Therefore, the fish and wildlife habitat management goals on private lands in the 1980s will first consider the interrelationships between primary land use and wildlife habitat. We will strive to maintain a reasonable balance between natural communities and land use and management. For example, the high rate of loss of valuable wetlands is a concern.

We know that competition for land by various high-demand uses will continue to endanger wildlife and its habitat. But we strongly believe that fish and wildlife habitat management goals and soil conservation goals have compatible long-range objectives. We also strongly believe that sound soil and water conservation programs, properly administered at all levels, can improve fish and wildlife habitat. For example, as treatment is applied to control high erosion rates on the nearly 145 million acres (58 million ha) of fragile rangelands in poor and fair condition, wildlife habitat quality should respond favorably. Habitat quality can also be increased by converting critically eroding cropland to areas of permanent vegetation. In addition, minimum tillage methods used successfully for erosion control in many areas have great potential for replacing fall plowing—and thereby increasing the supply of food and cover for wildlife—in many other areas.

Ideas for Program Improvement

A number of other challenges in resource management on private lands have undergone scrutiny during the RCA process, including water use and water conservation, range and forest management, animal waste management, urban conservation, and others. All of these challenges relate directly or indirectly to fish and wildlife habitat.

In studying these challenges, it is clear that the soil and water conservation problems faced by the nation today will be solved only with much more work on the land and with some redirection of present programs.

But for the first time we have developed several specific goals to guide us in our program planning and application. All are worthy objectives. We believe that all rural land users—and the general public, too—can recognize the value of these goals: (1) to reduce soil erosion on lands where the current rate of loss exceeds that considered acceptable to maintain soil productivity, so that food and fiber can be grown at reasonable cost; and (2) to protect wetlands with the highest values while giving due consideration to essential agricultural production.

Identification of the problems and from them setting desired objectives, however, is the easier part of a very complex equation; establishing procedures and programs for achieving the objectives and then implementing those procedures and programs is the more difficult part.

One approach would shift more responsbility for planning and carrying out conservation activities to state and local governments. If this approach were adopted, federal grant funds for soil and water conservation might have to be made available to states and local districts.

Such an approach appears to be in line with Administration thinking, since one of its stated aims is to provide government assistance that is competent, that uses funds efficiently, and that is administered as close to the field as possible. Secretary Block has said that the federal government, in wrestling with soil erosion, should encourage states to take more leadership "because the states are closer to the people."

Other approaches in the RCA package include:

1. Setting priority targets in critical resource problem areas where conservation programs would prove most cost-effective.
2. Placing more emphasis on applying complete on-the-ground conservation management systems in problem areas.
3. Trying out various conservation incentive plans on a limited, pilot basis to find out if they work. These plans might include conservation performance payments, conservation easements, contracts, low-interest loans, and tax incentives. The more successful approaches could then be tried in larger areas.
4. Redirecting some conservation research. One research aim would be to develop workable conservation tillage systems applicable to a wide range of conditions. Another would be to quantify the effects of soil erosion on soil productivity for different soils.
5. Improving the quality of resource information and making it available to land users quickly and in a form they can use.
6. Evaluating on a continuing basis the effectiveness of various USDA conservation programs in solving soil conservation problems.

These ideas are far from revolutionary, but they are a start. From our long study and from the recommendations and bills and hearings that will follow, we should see the emergence of a better program of resource management on private lands. While the challenges ahead are formidable, we take heart from past conservation achievements and the clear evidence that rural land users and the general public are alert to the need to protect our resources. They also indicate that they are prepared to back up their resolve with money and action. The conservation district movement in this country has been developed and led for the most part by farmers and ranchers—dedicated, committed people serving in a voluntary movement. Most serve without pay. They are convinced that soil and water conservation is good for farming and good for the country. Their commitment, encouraged at all levels by appropriate public programs, is our best hope for an improvement in sound resource management on the private land of the United States.

Strengthening Capabilities to Improve Resources Management

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International Association of Fish and Wildlife Agencies
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Cochairman and Moderator:
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Lessons From Past National Assessments of Wildlife and Fish: Information and Coordination Needs for the Future

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Introduction

In 1976 and 1980, the USDA Forest Service released assessments of the wildlife and fish resources on the nation's 1.6 billion acres (648 million ha) of forest lands and rangelands. Under the direction of the Forest and Rangelands Renewable Resources Planning Act of 1974 (P.L. 93-378), the next assessment is to be completed by 1990. That original direction has been supplemented by subsequent legislation, most notably the National Forest Management Act of 1976 (P.L. 94-588), and by several Congressional critiques of the 1975 and 1980 assessments.

Each assessment of wildlife and fish is part of a much broader analysis intended to describe the likely future availability, condition, use, and opportunities for improving the states of all resources on the nation's forests and rangelands. The analysis is also intended to provide an adequate basis for defining Forest Service assistance, management, and research programs.

In this paper, we briefly review the past assessments of wildlife and fish, the most serious shortcomings of those assessments, and current efforts to correct these shortcomings.

Past Assessments

The first assessment (USDA Forest Service 1977) was delivered to Congress less than 18 months after the Resources Planning Act became law. As a consequence, the content of the report was limited to bringing together available data.

This first effort to develop a comprehensive national analysis of wildlife and fish resources highlighted the problems involved in attempting a job of this magnitude. Two major, if seemingly obvious, conclusions were reached. The first was that there is no vast array of data "out there" that would be sufficient to answer the questions contained in the law. The second conclusion was that there existed more data and professional understanding about wildlife and fish resources than were utilized in the 1976 assessment.

As a consequence, in developing the 1980 assessment of wildlife and fish (USDA 1980) we focused our efforts on (1) developing a nationwide data base that could be constantly improved to better support future assessments, and (2) working with the states and with other federal agencies to ensure the best data available were included.

Our specific rationales for and approaches to the 1980 assessment have been reported in detail elsewhere (Schweitzer and Cushwa 1978, Schweitzer et al. 1978). Here we summarize what we attempted to do and our views on the adequacy of those efforts.

Developing a Data Base

A national wildlife and fish data base is necessary to meet the legal requirements for "an analysis of present and anticipated uses, demand for, and supply of" wildlife and fish resources and "an evaluation of opportunities for improving their yield of tangible and intangible goods and services." A further requirement that regionally significant issues be identifiable (U.S. General Accounting Office 1977) suggested that any analyses also deal with sub-national conditions.

For analytical purposes, identifying current and future demands and supplies requires defining the numbers and kinds of experiences and products that people want, the intensity of these wants or the prices that would be paid, the availability of experiences and products, and the costs of providing them. While some of this information had been compiled in state plans and special reports, such as the periodic national hunting and fishing surveys, it was necessary to work with the individual states to supplement these data. State data provided a basis for summarizing past trends and expectations for the near future of the numbers of people desiring wildlife- and fish-dependent activities and the availability of wildlife and fish resources to satisfy those desires.

No state felt it had credible information about the consumptive use of more than 40 species of wildlife and fish; the average state could provide such information about a dozen species or groups of species (Hoekstra et al. 1979). Credible information about nonconsumptive uses was essentially nonexistent (U.S. Congress 1980). As one might expect, population estimates were available for only a few species of high interest. Even estimates of relative changes in population levels over time were scarce.

There is relatively little quantitative substance to discussions about future demands and supplies in the 1980 assessment. We did include, for aggregates of states (Northeast, Rocky Mountains, etc.), relative comparisons of trends in consumptive use and populations from the mid-1950s through the mid-1980s for big game, small game, and upland game birds. While our intent was to base these comparisons on data supplied by the states, more judgment to fill in the holes was required than we would have preferred. The results are necessarily speculative. But we thought it important to start to demonstrate the sorts of information required in a national assessment.

In addition to requiring projections of demands and supplies, the Resources Planning Act requires that opportunities for improving anticipated situations be defined and the benefits and costs of these improvements be estimated. Information on both the quantity and quality of wildlife and fish habitat was inadequate to support a national assessment. Although numerous proposals or plans had been developed by the states and federal agencies (e.g. Colorado Division of Wildlife 1974), these plans could not be aggregated because they were not consistent in definition, they contained few clear indications of rationales, they made essentially no attempt to define the other resource outputs that would be foregone, and they did not sum to any comprehensive national set of opportunities. As a consequence, we began to develop a national data base that might eventually permit the definition of opportunities having these attributes.

It quickly became apparent that we would have to simplify the problem of dealing with the large variety of species by grouping species and also identify the implications to other resources of more intensive management of wildlife and fish. The work in the mid-1970s in defining species habitat relationships (Patton 1978) and grouping species on the basis of their habitat requirements (Thomas 1979), defined in terms that could be related to forest inventories, suggested the approach that was followed. In cooperation with many others, including states, federal agencies, and universities, we developed the first standardized national data base defining species occurrence and generalized habitat relationships for all resident and common migrant vertebrates in the United States by ecosystems within states.

In the 1980 assessment, some of this information was used for descriptive purposes, but little could be done to define quantitatively or analyze national opportunities to improve the condition of wildlife and fish resources. There were more inconsistencies, errors, and professional disagreements about the data than could be resolved in the available time (Hoekstra et al. 1979). However, as these problems are resolved, the data will become increasingly valuable, at least as a quickly available starting point for more closely examining possible options.[1]

Cooperative Efforts

In conducting the 1980 assessment, close cooperation with others was required for three reasons. First, the law mandates that assessments be cooperative efforts that fully consider the information and the desires of the states and others. A second, more pragmatic, reason for fuller cooperation was that the Forest Service

[1]Allen, D. N., C. H. Flather, T. W. Hoekstra, and G. E. Brink. A national assessment of wildlife and fish—A data base application. Unpublished manuscript on file at Rocky Mt. For. and Range Exp. Sta., Fort Collins, Colo.

did not have the capability to meet the comprehensive requirements alone, particularly where factors outside the agency's traditional purview were likely to be important. The third reason was that, without the involvement of numerous cooperators, even a perfect assessment would have little credibility and simply would not be accepted as a meaningful or useful product by the wildlife management profession.

Earlier it was mentioned that the individual states, territories and possessions provided information regarding past and prospective demands for, and supplies of, wildlife and fish. They did everything we asked, frequently in spite of their misgivings. But we have had enough feedback to realize that solely asking for data falls short of providing a mechanism for meaningful involvement in the assessment. It is clear that many of those who provided data are not convinced that a national assessment is of value to the nation or is relevant to their local concerns.

Other Perspectives

Several other flaws in the assessment have been pointed out by Congress and others. Three seem to us to be particularly important.

1. In response to a draft distributed in early 1979 for public review, many comments were received that there was no discussion of important policy issues regarding the treatment of wildlife and fish resources on the 187 million acres (75.7 million ha) in the National Forest System. There were expressions of belief that wildlife and fish were not receiving the same consideration given to commodity resources. Based on estimates developed in cooperation with the states, the Forest Service responded to this concern by establishing target population levels for those high-interest species where data and knowledge permit. This was an attempt both to provide a mechanism for monitoring the success of meeting habitat management goals and to ensure that those goals are explicitly considered before any resource management decisions are made. It remains to determine whether numerous data problems can be sufficiently resolved to make this an effective response to the concern.

2. A criticism focused on the substance of both past assessments is that, contrary to legal requirements, they have not provided an adequate "context" for proposed Forest Service activities; the rationales for assistance, management, and research activities are not adequately documented in the assessments. We agree that the wildlife and fish assessments do not provide the quantitative and analytically rigorous basis necessary to support particular actions. Likely improvements in basic data should lead to stronger future assessments.

3. A related criticism is that the assessment lacks credibility because resources are addressed one at a time. Given the finite limits of our lands and waters, it simply is not believed that we can produce more of everything to meet all desires. Indeed, the habitat base for wildlife and fish will continue to shrink as it has in the past (Poole and Trefethen 1978). We agree that it is no longer appropriate to describe the future as a time when the present "pie" of all resources will be larger and that it is necessary to focus on alternatives where some pieces of the pie will have to be smaller.

Future Needs and Progress

Based on our experience in conducting two national assessments, we categorize the major needs for making substantial improvements in the future as those related to data, to the development of an analytical model for working with those data, and to the development of meaningful cooperation in compiling data and in interpreting the results of analyses.

Data Needs

Except for a few recreationally and commercially important species, little quantitative information is available on either the use and values or supplies of wildlife and fish (Schweitzer 1980). Identifying opportunities that will be of the greatest benefit in the future requires projecting demands and availability of animal populations for human use. Because our understanding of the determinants of demand is rudimentary, projecting demands for these resources is essentially a matter of personal judgment.

At the time of the first assessment, in the mid-1970s, no state had a complete list of the vertebrates inhabiting the state; there was no standard system for defining or classifying wildlife or fish habitat, and there was no linkage between habitat data and inventory data of other resources. Tradeoffs among resources and thresholds where long-term harm to wildlife and fish resources would result could not be defined. While there has been limited progress in each of these areas, there still is not even a generally accepted conceptual basis and set of tools for developing inventories of habitat (Hirsch et al. 1979).

One of the basic problems is the sharply limited ability to quantitatively predict with confidence the results of habitat management in terms of animal populations. Thomas' work (1979) provides a first-stage, holistic basis for writing total land management prescriptions. And this work has been extended to "front-end load" National Forest land allocation decisions so that conditions and distributions of vegetation necessary for wildlife and fish are considered before, rather than after, major decisions are made. But the empirical basis for such an approach is seldom convincing, even to non-Forest Service biologists.

Analytical Model

The Resources Planning Act and related legislation make clear that the fundamental question to be addressed by a national assessment is not "What might be done to improve the condition of wildlife and fish?"; the central question is "What might be done to improve the welfare of people?" To the extent that it can be demonstrated in national assessments that maintaining or improving the condition of wildlife and fish is a necessary or advantageous means of contributing to human welfare, subsequent federal activities are likely to be more supportive of those resources.

There have been numerous demonstrations in the past that enhancing wildlife or fish would be advantageous—more turkeys would satisfy more hunters, or more salmon would support more families. But there has been relatively little success in demonstrating that it is to society's advantage to reduce or forego commodity production in order to produce more wildlife. Such tradeoffs are becoming increasingly necessary because of both physical limitations and budget limitations.

To this point, the assessments of wildlife and fish have not followed a written and explicit model that links human welfare to traditional biological considerations. That is, there has been no "game plan" to follow to demonstrate convincingly the advantages of spending available tax dollars on these resources rather than in some other fashion.

An adequate demonstration will require defining the implications to society as a whole if alternative combinations of wildlife, timber, minerals, and other resources were produced. In critical areas, "good enough" data will have to be developed and a wide range of efforts coordinated. Sociologists are needed to translate the notion of human welfare into operational terms; is it enough to focus on employment and income, or must we also decide what is meant by quality of life? Ecologists and biologists are needed to define the quantities and mixes of all resources that could be produced without damaging natural systems. And economists are needed to identify the production possibilities that promise to contribute most to human welfare for particular levels of available tax dollars.

The cost of failing to develop this information is that the past will be repeated—reasonable treatment of wildlife and fish resources will continue to depend solely upon the profession's political muscle. There is no denying that this approach has had some impressive results in the past. But continuing to rely on this approach would mean that the opportunity afforded by the Resources Planning Act would be lost.

Need for Cooperation

Our experience suggests that improvements in future assessments of wildlife and fish resources will be a direct function of improvements in the substantive content of cooperation among federal and state agencies. This requires moving beyond data-sharing to jointly defining the questions that are important and jointly interpreting compiled data.

We recognize that cries for meaningful cooperation are a tradition at conferences such as this. Perhaps the cries have borne fruit, for some progress has been made.

In 1977, personnel from the Forest Service and the Fish and Wildlife Service began to explore means of coordinating efforts in classifying and inventorying wildlife and fish habitat. This and other efforts to improve coordination led to a formal Interagency Agreement Related to Classifications and Inventories of Natural Resources among five federal agencies—Bureau of Land Management, Soil Conservation Service, and Geological Survey are also included—to coordinate their efforts. To ensure that the states are represented in discussions and decisions, formal cooperators include the National Governors Association, the Council of State Planning Agencies, the National Conference of State Legislatures, and the Council of State Governments.

Concerns for the same sorts of problems were expressed in a special session of this Conference two years ago (Cushwa 1979, Petoskey 1979). As a follow-up to that session, representatives of federal agencies, the International Association of Fish and Wildlife Agencies, the Wildlife Management Institute, the National Wildlife Federation, and others met to develop a strategy for implementing the recommendations that had been made. One decision was to develop a standardized taxonomy for the nation's vertebrate species (Cushwa and Gravatt 1980). A second decision was to strengthen research and development efforts of the Forest Service focused on preparing for future assessments. An interagency fish and wildlife coordination group was established at Fort Collins, Colorado, under the administration of the Resource Evaluation Techniques (RET) Program of the Rocky Mountain Forest and Range Experiment Station.

Wildlife and fisheries biologists from the Fish and Wildlife Service, Bureau of Land Management, Soil Conservation Service, Forest Service, and one state (Maryland) are assisting the RET Program to develop techniques for land and aquatic classification, for developing habitat inventory procedures, and for defining the information needed to support national assessments and planning for wildlife and fish resources. They have provided major assistance in defining researchable problems in estimating future potential levels of wildlife and fish production and have contributed to the preliminary development of an analytical model to support national renewable resource assessments.

Each federal agency is dependent upon information generated by the states. In cooperation with other federal agencies and individual states, the Fish and Wildlife Service is testing a standardized procedure for describing fish and wildlife resources on a state-wide basis. Wildlife and fish agencies in Colorado, Maine, Minnesota, Missouri, and Pennsylvania are currently summarizing data within this general framework. DuBrock et al. (1981) discuss the experience to date in detail.

It is difficult to coordinate federal and state work, both because of differences in specific interests and orientations and because of bureaucratic and political sensitivities. A major impairment is the lack of orderly and meaningful communication on purposes, needs, and responsibilities for coordinated development of wildlife and fish resource assessments. Therefore, in developing the 1980 assessment, the Forest Service asked each governor to appoint a single person through whom all requests for assistance could be channeled. It is not yet clear whether the recent establishment of the Interagency Agreement (and of the interagency fish and wildlife coordination group) will lead to a change in procedure in developing future assessments.

Summary

The Forest Service, through the Department of Agriculture, has the legal obligation to periodically produce national assessments of wildlife and fish in cooperation with the states and others in a manner that is responsive to the concerns of both cooperators and the general public. While the 1980 assessment was an improvement over that released in 1976, it fell short of meeting the requirements of the Resources Planning Act.

Experience in these efforts suggests there are three areas in which improvements are needed if the usefulness of future assessments is to be increased. The data that describe wildlife and fish resources and their habitats and uses must be improved. While there has been significant progress in identifying the information that is required for management and evaluation and in compiling that information, the national assessments clearly demonstrate that we have little quantitative information about the tradeoffs among resources implied by alternative management programs or about the thresholds where long-term damage might be sustained.

The second need is to develop an analytical model. It is not enough to simply summarize a compilation of information . A logical process of evaluation and interpretation is required to clearly state why tax dollars—which are likely to be in shorter supply in the future than has been true in the recent past—should be spent on wildlife and fish resources rather than to meet some other pressing need.

The final need is to continue recent trends in developing coordination among federal and state agencies. While progress has been substantial, it is not easy for any institution to surrender prerogatives of control in order to achieve more "meaningful" cooperation. Presumably, cooperation will improve as the benefits of producing sound assessments are displayed in a more convincing manner.

Many decisions have not yet been made—and probably will not be made for several years—on precisely how the 1990 RPA assessment will be conducted. In particular, procedures for involving cooperators in a meaningful way have not been fully negotiated among federal and state agencies. We see this void as an opportunity for those interested in wildlife and fish resources to offer their ideas on how this might best be done. With your help, periodic national assessments of wildlife and fish can lead to the most appropriate treatment of those resources.

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State-of-the-Art of Fish and Wildlife Species Information Systems in the United States

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Introduction

During the past two decades, laws like the National Environmental Policy Act, Clean Air Act, Federal Water Pollution Control Act, Forest and Rangelands Renewable Resources Planning Act, Endangered Species Act, Marine Mammal Protection Act, and many others have signaled a change in information needs for planners and managers of our fish and wildlife resources. One of the most significant changes has been a shifting emphasis to total resource management. Most natural resource agencies traditionally have been concerned with "featured species" management and inventory (Cushwa and DuBrock 1981, Thomas 1981). In addition to requiring a different approach to natural resource planning and management, legislation within the past two decades has required periodic national inventories and assessments of natural resources, including fish and wildlife.

To respond to changing information needs and management priorities, fish and wildlife professionals have developed computerized data storage and retrieval systems to facilitate planning and management decisions. The advantages of computerized systems include: (1) more efficient data analysis for large data sets, (2) a reduction in the time and cost of handling data, (3) exploration of ecological analysis, and (4) rapid testing of fish and wildlife models to predict effects of alternative management strategies. It is the intent of this paper to identify and explore the progress made in the development of state and federal computerized fish and wildlife species information systems over the past few years.[1]

The information systems presented in this paper represent a state-of-the-art analysis of fish and wildlife species information systems. The paper focuses on species data and not the computer/program aspects of information systems. Also, bibliographic and geographic information systems are not considered in this report, unless specific species data sets are associated with the systems.

Reviews of fish and wildlife species information systems that have been most helpful in the preparation of this paper include: Anderson (1979), Armentano and Loucks (1979), Hoekstra and Cushwa (1979), NUS Corporation (1979), Tucker and Huber (1980), and Olson (1980).

Overview of Fish and Wildlife Information Systems

This review summarizes the efforts of seven federal agencies (Forest Service, Fish and Wildlife Service, Bureau of Land Management, Soil Conservation Service, Corps of Engineers, Environmental Protection Agency, and the Department of Energy), four state agencies (Texas, Kansas, Colorado, and Virginia), and three

[1] For the purpose of this paper, a fish and wildlife species information system is defined as a data base, set, or file that contains various kinds of information about individual species. Fish and wildlife refers to any or all vertebrate and invertebrate animal taxa.

private organizations/universities (The Nature Conservancy, Cornell Laboratory of Ornithology, and the University of Notre Dame). These systems were selected as representative samples of the state-of-the-art of computerized fish and wildlife species information systems.

Forest Service, U.S. Department of Agriculture[2]

The Forest Service (FS) has seven operational fish and wildlife species information systems. Six of these information systems have been developed at the FS regional level for systematically integrating biological information in forest management planning. The systems include: WILDO1, FS Region 1 (Anonymous 1980a); RUN WILD, FS Region 3 (Patton 1979); Wild RAM, FS Region 4 (Anonymous 1980b); Western Sierra Wildlife/Habitat Relationships Program (WHR), FS Region 5 (Hurley and Asrow 1980); Wildlife-Habitat Relationships Data Base (WILDHAB), FS Region 6 (Knight and Purcell 1980); and Wildlife Management Information System (WMIS), FS Region 9 (Anonymous 1980c).

In addition to the above, the FS has developed a nationwide fish and wildlife species information system in response to requirements set forth by the Forest and Rangelands Renewable Resources Planning Act (RPA) of 1974. RPA requires periodic national assessments of all renewable resources, including fish and wildlife, on forest and rangeland of the U.S. and the development of information bases that could be used to answer specific national and regional questions regarding these renewable natural resources (Schweitzer et al. 1978, 1981, Schweitzer and Cushwa 1978, Hoekstra et al. 1979).

Species coverage varies with each FS information system, but all emphasize vertebrates. Birds, mammals, reptiles, and amphibians are common to all the systems. Fish are included in all but WHR. RPA is the only system that includes invertebrate species; however, plans are underway to add invertebrates to the Wild RAM species files (D. Winn, U.S. Forest Service, Region 5, Ogden, Utah; pers. comm.).

All the FS fish and wildlife information systems include the following data elements: common and scientific species names; species distribution by State, county, and national forest; species legal or protection status; species-habitat association for feeding and reproduction; and species relationships to special or unique habitat features. Additional data elements that have been included in at least some of the information systems include: reproductive potential and performance (WILDO1, WILDHAB); relative abundance within a national forest (WILDHAB, WILDO1, WMIS), county (WMIS), state (WILDHAB, WMIS, RPA); and food habits (WILDO1, WMIS, Wild RAM, WHR, WILDHAB, RUN WILD).

There is considerable variation in standards and definitions used for the data elements in each of the systems. In some cases it is difficult to discern, but data elements including scientific and common names, habitat classifications, county designations and abundance all vary from system to system. For example, some information systems use scientific and common names from reference documents, while others employ specific sources like the American Ornithological Union

[2]Much of the information presented for this agency was derived from reports distributed at a Forest Service-sponsored fish and wildlife habitat workshop, April 1980, in Denver, Colorado.

checklist for bird names. Some of the information systems designate numeric codes for species by taxonomic group, but the numbers differ from one system to the next. Most of the information systems include species distribution by county, state, and national forest. However, some use Federal Information Processing Standard (FIPS) codes for county and state designation, while others use truncated names or spell out the name entirely.

Habitat classification also varies with each information system. WILDO1 and Wild RAM use a vegetation classification system developed for Montana (Pfister 1977). WILDHAB, WHR, and RUN WILD also use vegetation classifications developed for their specific regions. WMIS and the RPA information system use other habitat classification schemes such as ecoregions (Bailey 1978) and potential natural vegetation (Küchler 1964).

The basic approach taken by the FS has been to develop customized information systems (input format and programs) on a regional scale, with one exception. WMIS is being developed on a state-by-state basis and when completed will be integrated into a regional information system as well. Also, WMIS is being developed using an existing format called "A Procedure for Describing Fish and Wildlife" (Mason et al. 1979). The methodology developed by Mason et al. (1979) is discussed below.

Seven of the eight FS regions have computerized fish and wildlife information systems. This provides or will provide systems' coverage for 37 of the 48 states in the continental U.S. All the information systems mentioned above are operational, except for WMIS (Region 9).

Fish and Wildlife Service, U.S. Department of the Interior

Seventeen fish and wildlife species information systems were identified within the Fish and Wildlife Service (FWS). Fourteen are operational and three are under development. Ten data bases are avian population specific, while the others contain a variety of species. All of these information systems have been developed by a FWS research facility or the Office of Biological Services (OBS).

The Migratory Bird and Habitat Research Laboratory (MBHRL) and Office of Migratory Bird Management (MBMO) maintain ten species information systems. All MBHRL and MBMO information systems are devoted to avian information, and two include a single species. Hoekstra and Cushwa (1979) provide an excellent review of computerized avian data storage and retrieval systems in the northcentral and northeastern U.S.; it includes six of the 10 MBHRL/MBMO information systems.

The 10 FWS avian information systems are: The Woodcock Survey, Mourning Dove Survey, Coastal and Marine Bird Data Base (Anderson et al. 1980), Breeding Bird Census (BBC), Breeding Bird Survey (BBS), Winter Waterfowl Survey, North American Bird Banding Record, and RUN WILD format (Patton 1978) systems for the states of Alabama, Pennsylvania, and West Virginia.

Migratory waterfowl are common to all the avian information systems with more than one species. Shorebirds, passerines, songbirds, and some raptors are included in all but the Coastal and Marine Bird Data Base and Winter Waterfowl Survey. In addition to waterfowl, the Coastal and Marine Bird Data Base includes shorebirds, seabirds, and colonial nesting species.

The FWS avian information systems include the following data elements: route location/special distribution by county, state, or latitude and longitude (all); relative abundance (Woodcock, Mourning Dove, Coastal and Marine Bird Data Base, BBS, BBC); survey weather conditions (Woodcock, Mourning Dove, Coastal and Marine Bird Data Base, BBS); and habitat association (BBS, BBC, Alabama, Pennsylvania, West Virginia, Winter Waterfowl, Bird Banding Data). The Bird Banding system has additional data on bird age and sex, general health, and recovery dates. The avian data Alabama, Pennsylvania, and West Virginia systems are in the FS RUN WILD format.

The remaining seven FWS species information systems have been developed by or for OBS National Teams. These information systems are: RUN WILD EAST—West Virginia and Alabama (Cushwa et al. 1978); "A Procedure for Describing Fish and Wildlife"—Pennsylvania (Mason et al. 1979); Species Data Base (National Coastal Ecosystems Team 1981); Northern California and Pacific Northwest Coastal Characterization species systems (developed for the National Coastal Ecosystems Team); and a terrestrial species data base (Asherin et al. 1979).

Species coverage varies with each of these information systems. The Northern California and Pacific Northwest Coastal Characterizations, the RUN WILD EAST systems, and "A Procedure for Describing Fish and Wildlife" include comprehensive lists of vertebrate species, and selected invertebrates. The terrestrial species data base includes only amphibians, reptiles, birds, and mammals. The Species Data Base is specific for aquatic species—fish, molluscs, and aquatic crustaceans.

All the OBS-sponsored fish and wildlife information systems include the following data elements: common and scientific species names; species legal or protection status; population trends or relative abundance; distribution by state ("Procedure," Species Data Base), county (RUN WILD EAST, "Procedure"), latitude and longitude ("Procedure," and Species Data Base), watershed (Coastal Characterizations); habitat association by season (Coastal Characterizations and "Procedure"), by life stage ("Procedure" and Species Data Base), by selected or special habitat features ("Procedure," RUN WILD EAST, and Species Data Base); and references. Additional data elements included in at least some of the information systems: food habits ("Procedure," RUN WILD EAST, and Species Data Base); reproduction (Species Data Base); and population descriptors ("Procedure" and Species Data Base).

The terrestrial species information system was developed by the Western Energy and Land Use Team for use in developing and evaluating the rapid assessment methodologies (Asherin et al. 1979). The system is currently being used to test guilding criteria for the Habitat Evaluation Procedures (HEP).

As with the FS systems, there is considerable variation in data element standards and definitions. For some systems there were no standards used for data compilation; e.g., the RUN WILD EAST systems in Alabama and West Virginia, while others standardized every data element; e.g., "A Procedure for Describing Fish and Wildlife" in Pennsylvania.

Classification for associating species with habitat vary with each system. Some of the systems use general habitat descriptions that were generated by the data compiler; e.g., RUN WILD EAST, while others use existing classifications. For example, the Species Data Base uses the wetlands classification system (Cowardin et al. 1979) adopted by the FWS (National Coastal Ecosystems Team 1981). The BBS uses potential natural vegetation (Küchler 1964) and ecoregions (Bailey 1978). "A Procedure for Describing Fish and Wildlife" uses all of the above and also includes Society of American Foresters (SAF) forest cover types (SAF 1954) and the U.S. Geological Survey land use and land cover classification (Anderson et al. 1976).

All FWS information systems have been developed for a particular interstate region, or national survey, except the Eastern Energy and Land Use Team (EELUT) systems. Limited prototype applications of EELUT information system efforts have been on a state-by-state basis. Species information systems using "A Procedure for Describing Fish and Wildlife" as a methodology are being developed in Pennsylvania, Missouri, Minnesota, and Colorado.

Fourteen of the 17 FWS species information systems are operational. The two Coastal Characterization systems are stored on tape and have no associated software. The Species Data Base (National Coastal Ecosystems Team 1981) is under development at this time.

Bureau of Land Management, U.S. Department of the Interior

The Bureau of Land Management (BLM) is developing a habitat inventory system (IHICS) that contains wildlife species information (BLM 1978). This inventory is being conducted in response to requirements of the Federal Land Policy and Management Act (FLPMA) of 1976, which directs BLM to maintain a continuing inventory of all public lands and their resources (Kerr and Brown 1978, Hirsch et al. 1979). IHICS includes information on amphibians, reptiles, birds, and mammals compiled from specific habitat surveys on BLM districts. The system includes the following standardized data for each survey site: species scientific name; species relative abundance; species legal status; species use of habitat types by season and for feeding, breeding, and cover; special habitat features; and habitat association by vegetation and physiographic region. IHICS inventory data for BLM districts has been collected, but much of the data has not yet been computerized. Computer programs for storage and retrieval are being developed.

Soil Conservation Service, U.S. Department of Agriculture

The Soil Conservation Service (SCS) is developing a fish and wildlife information system (Hirsch et al. 1979), but it is not currently operational. The SCS, in response to the Soil and Water Resources Conservation Act (RCA) of 1977, is required to appraise the status, condition, and trend of certain natural resources on all non-federal lands. A 1979 national appraisal was completed, but without fish and wildlife information; however the 1985 appraisal will include fish and wildlife parameters from the data base under development. Specific fish and wildlife data elements and classifications have not yet been identified, nor has species coverage been established. Activities concerning the development of this fish and wildlife information system are being coordinated through the Office of the Chief Biologist, SCS, Washington, D.C.

U.S. Army Corps of Engineers, Department of Defense

The U.S. Army Corps of Engineers (COE), with financial cooperation from the Office of Endangered Species, FWS, developed the Sensitive Wildlife Information

System (SWIS) in the mid-1970s. This information system contains narrative accounts on the biology and distribution of approximately 100 selected mammal, bird, reptile, amphibian, fish, and invertebrate species; special emphasis is given to Federal "endangered" or "threatened" species. Species descriptions are arranged by state and include: distribution by county; protection/legal status; behavioral characteristics and habitat requirements; population structure and trends; food habits; and references (U.S. Army Corps of Engineers 1977).

The Species Data Base (National Coastal Ecosystems Team, FWS) is being developed for the COE, Mobile District, for assessing the impacts of navigation and dredging activities on fish and shellfish (National Coastal Ecosystems Team 1981).

U.S. Environmental Protection Agency

A review of the Environmental Protection Agency's (EPA) data systems (EPA 1980) revealed only one that qualified as a fish and wildlife species information system. BIO-STORET was developed in the mid-1970s at EPA's Methods Development Laboratory, Cincinnati, Ohio, in response to information needs outlined in federal water legislation (Weber and Silver 1978). BIO-STORET system includes information on zooplankton, microinvertebrates, macroinvertebrates, and some vertebrates, as well as plant species. This system interfaces with the physical and chemical water-related data base (STORET). The BIO-STORET system includes: a standard hierarchical classification of all freshwater and coastal species; species distribution by watershed, Office of Water Data Coordination Catalog (OWDC) Units, state, county, and latitude and longitude (Weber and Silver 1978). Data can be retrieved by taxon, date of collection, sample type, location, standard biomass units, or many other environmental factors. BIO-STORET is operational and data is being input into the system on a selective basis.

U.S. Department of Energy, National Laboratories

Within the last few years, Brookhaven National Laboratory has developed a computerized data base of animal and plant species (ESUSA) of concern to the Office of Endangered Species, FWS. Species listed as review and candidate species are included, as well as those listed and proposed as threatened or endangered. The information included for 1,275 animal species is: common and scientific name; animal group; FWS listing and recovery priorities; federal legal status; geographic distribution by state, county, and island, *Federal Register* citations; and information sources for the species' recorded distribution (Nagy and Calef 1979).

Taxonomic group names follow those used by FWS in the Federal Register. Scientific names (genus and species) are handled by including the most widely accepted scientific name followed by synonyms in parentheses. County level location data is encoded using FIPS codes. Species lists can be generated by state, county, taxonomic group, status, or an entire species record can be printed.

The Environmental Sciences Division, Oak Ridge National Laboratory, has developed an information system for regional energy-related assessment and planning, called GEOECOLOGY (Olson et al. 1980). One of the many data categories is wildlife, which has 15 data sets. Seven data sets are derived from the Breeding Bird Survey data base discussed earlier, three data sets are devoted to endangered species (Brookhaven ESUSA file), and the remaining five data sets include mammal range maps and distribution data compiled from literature surveys. Species distribution information is retrievable at the county, ecoregion, and physiographic strata.

State Agencies

Texas has developed the Texas Natural Resources Information System (TNRIS) from what was originally the Texas Water Oriented Data Bank. This system contains information gathered in Texas by various state, federal, and private organizations on: water resources, biological resources, meteorological resources, geologic and land resources, and socio-economic resources (Texas Natural Resources Information System 1977). Twelve separate files make up the animal subcategory of the biological resources category. Harvest data for shrimp, fish, dove, deer and turkey occupy six files. Additional files contain information on bay systems, sample data from surveys of the Texas Gulf Coast, white-tailed deer movement data from telemetry studies, bird banding recoveries, fish stocking, and southern pine beetle control operations. Both graphical and statistical software are associated with this system.

The State Biological Survey of Kansas has developed computer files of aquatic invertebrate fauna of the State. Over a million specimens have been collected during the past seven years. Computerized data files now are being created at the University of Kansas using the SELGEM system (letter dated 12/5/80 from R. L. McGregor, Director).

The Colorado Division of Wildlife, Nongame Section, has computerized distribution, status, habitat association and relative abundance data for four animal groups: birds, mammals, reptiles, and amphibians. This data has been published in three LATILONG studies (Kingery and Graul 1978, Bissell 1978, Langlois 1978). The information in this system is based on latitude and longitude blocks and organized by species.

The Virginia State Information System (known by various acronyms including SIS and VARIS) was developed in the Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University. This sytem contains county level data for the entire State. The biological data files include county distribution of mammals, reptiles, amphibians, and rare and endangered species; and narrative descriptions or phenotypic features, habitat associations, breeding information and requirements (Tucker and Huber 1980).

In addition to the above systems, the following states have automated inventory systems of some type for game and fish management (NASIS 1979): Alaska, Arizona, Delaware, Florida, Georgia, Hawaii, Indiana, Kansas, Louisiana, Minnesota, Nevada, New Jersey, New Mexico, New York, North Carolina, Oregon, Tennessee, and Wisconsin.

Private Organizations and Universities

The Nature Conservancy has instituted State Natural Heritage Programs in 24 States and the Tennessee Valley Authority (Tucker and Huber 1980). Each Natural Heritage Program is an inventory process for identifying significant and unique natural elements, such as plant communities, geologic features, special plant and animal species, and aquatic habitat types within each state (Sanders 1978, The Nature Conservancy 1978). Generally, following a two-year program development and testing phase, which is conducted under contract with a state, the Natural Heritage Programs and their computerized systems are incorporated into state government activities.

The faunal element of a State Heritage information system includes those species of particular concern because they are classified by the federal or state governments as "endangered," "threatened," "rare," "peripheral," "endemic," or otherwise designated as being of special interest. Federal and state endangered and threatened species lists are used as well as assistance from knowledgeable individuals throughout a state, to identify species for inclusion in the data base (Arkansas Natural Heritage Inventory Program 1980).

Each State Heritage data base is a collection of cross-referenced manuals and computerized files. Computerized files abstract occurrence data in summary form and include: species name; occurrence by state, county, USGS quad map name, and latitude/longitude coordinates of the species; relative population; and a description of the site as an index number cross-referencing the entry to a manual file that contains information on present and past distribution, life history, status, reasons for special status, and phenotypic description (Moyseenko et al. 1978, The Nature Conservancy 1978). The USGS quad map name cross-references the species distribution to a manual geographic file and map file for access and retrieval.

The Computerized Biology Data and Program Bank at the University of Notre Dame (BIOBUND) contains numerous data files on the biota and ecology of Indiana (Tucker and Huber 1980, Armentano and Loucks 1979). The only faunal representation is 170 species of nesting birds. Species distribution is indicated by county at various life stages.

The Cornell Laboratory of Ornithology has developed an information system on nesting birds (Tucker and Huber 1980). The Colonial Bird Register (CBR) is a computerized data base for the collection of information concerning approximately 70 species of colonial nesting birds. Data is obtained from field survey forms and includes information on species; colony name, history, size, number of nests, nesting state, substrate, habitat description, human activity levels, state, county, latitude and longitude, time of day, weather information, month and year.

Discussion of Species Information Systems

The need for standard habitat classifications and definitions for computerized fish and wildlife systems has been established by Hirsch et al. (1979) and Besadny (1979). They suggested that standards were needed to maximize the utility of these systems for state and federal natural resource agency planning and management. However, the need to reduce costs involved in the management of natural resources computer systems actually was recognized in the early 1960s with an agreement of data sharing between two Department of Interior agencies, the Federal Water Quality Administration and the U.S. Geological Survey. Other attempts to "standardize" natural resource data information systems have largely failed due to the changing structure of agencies to meet different information needs, inconsistent funding for development and maintenance purposes, and lack of agreement on attributes of the systems themselves. In spite of these problems, many of today's systems possess common attributes.

The following comparisons examine whether it is possible to aggregate species information from existing systems for local, state, regional, or national purposes. For example, can the federal land management agencies (i.e., FS, BLM, and SCS) use existing systems to complete national assessments of fish and wildlife resources now required by federal legislation (RPA, RCA, and FLPMA)? Two different approaches to developing system formats are apparent from this review. One approach is to develop a format that will serve specific uses. This is the most common approach. A second approach is to develop a generalized, flexible, comprehensive format that will meet the needs of multiple users for broad geographic areas. Both methods have trade-offs in terms of specificity and cost considerations. What is "too much" and "too little" often depends on the eye of the beholder.

In order for a resource manager to use information compiled by either of the above approaches, the following four factors must be considered:

1. Geographic coverage—Does the information in the system cover the particular geographic area that you must consider; e.g., a county in Virginia, or the Roanoke River, or the continental U.S.?
2. Species coverage—Does the system include particular species of greatest interest, target species, or all the animals in the geographic area?
3. Data elements used to describe a species—What information is included on each species? Does this system include species distribution at the county level? Are species associated with a habitat type?
4. Definitions/Classifications—Are standard definitions and classifications used? For example, what vegetation classification system is used for associating species and habitat? Is it a classification used by my agency? If I need to get information from two different systems, are the definitions and classifications compatible so that I can combine data from the two systems?

Fourteen of the "major" information systems covered in the overview section are used to illustrate these parameters. Table 1 shows that 10 of the 14 information systems provide county level distribution data for all vertebrate species (except WHR-Fishes). In addition, four of the systems include aquatic and terrestrial invertebrates. All but two systems specify standard common and scientific names and five systems relate species-habitat associations for reproduction and feeding. Common data elements with the "Habitat Association" category vary widely by system.

For geographic coverage, two basic approaches have been used in developing fish and wildlife species information systems—an intrastate/interstate regional approach and a state-by-state approach. Most of the federal agency systems have been developed with a regional perspective, while the State Heritage Programs and the Eastern Energy and Land Use Team, Fish and Wildlife Service, have used the state-by-state approach.

Many systems emphasize vertebrate taxa (amphibians, reptiles, birds, mammals, and fishes), and some include invertebrates; however, information on invertebrate taxa are not complete for most systems (Table 1). For example, the invertebrate category for the "Procedure" covers all freshwater bivalve molluscs, but only 100 selected aquatic and terrestrial insects based on significance as "indicator" species, threatened and endangered, commercial/economic importance and food species. Also, some of the systems are specific for endangered/threatened and selected other species; e.g., SWIS, ESUSA, and the State Heritage Programs.

Species coverage, geographic coverage, and species data elements are all critical in determining whether an information system has the type and quantity of species information needed to answer questions. Standard data element definitions are the critical parameters once data is obtained and must be used. It should be noted that definitions/classifications vary widely among the systems reviewed. For example, species-habitat association might be indicated using Küchler (1964), Bailey (1978), Cowardin et al. (1979), Society of American Foresters (1954), Anderson et al. (1976), and/or a variety of regional habitat classifications.

To generalize, within the systems reviewed, data element definitions were standardized. However, among systems there were few definitions that were commonly used. Also, the hardware (computers) and software (programs) varied widely. Thus, it would be very difficult to combine data from two different systems.

Opportunities for Utilizing Fish and Wildlife Information Systems

We envision a wide range of applications for fish and wildlife species information systems. Present applications include species lists and data for environmental impact assessments, forest management planning, and species inventories. Potential applications, identified in an evaluation of our methodologies (Cushwa et al. 1980), include: preparation and evaluation of water and mining permit applications; airport, power plant, and recreation area sitings analyses; ecological planning inputs for state and federal land management agencies; environmental education and extension; and other applications. In addition, a variety of geographic information systems have been developed in the last decade, all dependent upon various biotic and physical data sets. Species information systems should be developed to interface with these existing geographic information systems for added dimensions using computer graphics.

There undoubtedly are a number of "correct" ways to design and implement species information systems. One way, which is being tested in EELUT efforts to design and establish statewide species information systems, is an interagency committee approach (Cushwa and Gladwin 1980). This approach establishes a framework for involving all data users in the design, implementation, and management of a species information system. This committee (a) identifies user needs, (b) develops standard data elements and definitions, (c) identifies sources of funding, and (d) establishes system management policy.

We believe more concentrated efforts by both federal and state agencies will be made during the 1980s to facilitate data exchange and the cost-effectiveness of developing and implementing computerized species information systems. Progress is being made. For example, the Interagency Agreement related to Classifications and Inventories of Natural Resources signed by the FS, FWS, SCS, USGS, and the Bureau of Land Management in 1978. This federal interagency group is cooperating with the International Association of Fish and Wildlife Agencies and various associations representing states to standardize and coordinate classifications and definitions. Recent accomplishments include a contract undertaken by the Association of Systematics Collections to develop a standard national list of fish and wildlife species names and the Integrated County-Level-Data User's Workshop (Olson 1981).

We have progressed remarkably since the late 1960s, when there were no computerized statewide, regional, or national comprehensive fish and wildlife

Table 1. Summary of major fish and wildlife species information systems.

Information system name and owner	Geographic coverage by state	Animal groups											Computerized data elements used to describe each species[a]								
		Operational	Standard definitions	Amphibians	Reptiles	Birds	Mammals	Fishes	Crustaceans	Molluscs	Terr. insects	Aqua. insects	Common & scientific names	Legal status	Distribution	Habitat association	Relative abundance	Food habits	Reproduction	Management practice	References
WILD01; Forest Service, Region 1	MT, ID	×	×	×	×	×	×	×					Cm	Fd, St	NF,St	R,Fe,SHF	NF	G	×		
WILDHAB; Forest Service, Region 6	OR,WA,CA	×	×	×	×	×	×	×					Cm, Sc	Fd,St	NF,St	R,Fe,Cv, SHF	NF,St	G	×		×
WildRAM; Forest Service, Region 4	ID,UT,WY,NV	×		×	×	×	×	×					Cm, Sc	Fd	St,Co,NF NP	SHF,SE		G			
WHR: Forest Service, Region 5	CA	×	×	×	×	×	×						Cm, Sc	Fd,St	Co	SHF,Se,R, Fe,Cv					
RUN WILD; Forest Service, Region 3	NM,AZ	×	×	×	×	×	×	×					Cm, Sc	Fd,St	Co,NF	SHF,Cv,G		G		×	×
National Data Base (RPA); Forest Service, RET	National	×	×	×	×	×	×	×	×	×	×	×	Cm, Sc	Fd	St,Co	R,Fe,Cv, SHF	St				
A Procedure for Describing Fish and Wildlife; Fish and Wildlife Service, EELUT	PA (MN, MO, CO, under development)	×	×	×	×	×	×	×	×	×	×	×	Cm, Sc	Fd,St	St,Co,LL Q,OWDC	R,Fe,Cv, Se,SHF,LS, NWI	St,Co	LS,Se		×	×
RUN WILD EAST; Fish and Wildlife Service, EELUT	WV,Al	×		×	×	×	×	×	×	×	×	×	Cm, Sc	Fd	Co,St	Cv,SHF,G		G		×	×
Species Data Base; Fish and Wildlife Service; NCET	AL,MS	×						×	×	×			Cm,	Fd,St	LL,LS	LS,NWI,R	LL	LS,G	×		×

SWIS[b]; U.S. Army Corps of Engineers, WES, Vicksburg, MS	National	×		×	×	×	×	×					Cm, Sc	Fd	Co,St	G	St	G	×	×
ESUSA[b]; Brookhaven National Lab, Upton, NY	National	×	×	×	×	×	×	×	×	×	×	×	Cm, Sc	Fd	Co,St	G				×
GEOECOLOGY[c]; Oak Ridge National Lab, Oak Ridge, TN	National	×	×			×	×						Cm, Sc	Fd	Co,St					
WILDATA (LATILONG); Colorado Division of Wildlife, Denver, CO	CO	×	×	×	×	×	×						Cm	Fd,St	LL	G	St			
State Heritage Programs[b]; The Nature Conservancy, Arlington, VA	SC,TN, WV,NC, KT,MS,AR,OH, NM,OK,OR,IN, WA,RI,WY,MA, MN,CA,CO,AZ, MD,SD,ND,MI (Federal-TVA)	×	×	×	×	×	×	×					Cm, Sc	Fd,St	St,Co	SHF,G	St			

[a]Data Element Codes
Cm = common; Co = county; Cv = for cover; Fd = Federal; Fe = for feeding; G = general; LL = latitude and longitude; LS = by animal life stage; NF = national forest; NP = national park; NWI = National Wetlands Inventory; OWDC = Office of Water Data Coordination Cataloguing Units; Q = 7½′ quadrangles; R = for reproduction; Sc = scientific; Se = by season; SHF = for special habitat features; St = State; × = data present.
[b]Species coverage is restricted to endangered, threatened, and select species.
[c]In addition to birds and mammals, GEOCOLOGY includes endangered/threatened species lists from the ESUSA system.

species information systems. However, as stated by Hirsch et al. (1979) and Besadny (1979), there are still problems with data element standardization and coordination. Continuing coordinated state/federal efforts will result in the efficient development of computerized species information systems that can be used to facilitate many natural resource planning, management, and research purposes.

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The National Wetlands Inventory and Its Relationship to Wildlife Habitat Values in the Southwestern United States

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Introduction

In this conference on "Resource Management for the Eighties" we place a heavy emphasis on the wildlife and wildlife habitat interpretations of the word "resource." There are of course more universal meanings. Erich Zimmerman's (1951) definition suggests that the word ". . . . does not refer to a thing nor a substance but to a function which a thing or substance may perform or to an operation in which it may take part. . . . " A resource may be culturally defined when individuals attribute a value to it associated with qualities of life. A resource may be technically defined as material commodities so as to satisfy wants. As Zimmerman states ". . . . resources are not, they become."

We might be hard pressed to prove our interpretations as essential ones to society given this more comprehensive definition. Wildlife and wildlife habitat values play a significant role in defining resource management nowadays. This role is anything but trivial or nonessential. The way in which the collective social groups of this nation manage this resource may prove to be a true test of our civilization. The web of events, policies and policy objectives set forth in our past (NEPA 1969 42 U.S.C. 4321 et seq.) brought a significant change in how society views wildlife and its management. Now, twelve years later we can begin to see what progress has been made and where it will lead us.

In this paper we shall outline the United States Fish and Wildlife Service's National Wetlands Inventory Project and its products and relate this contribution to the future resource management picture. This picture is the result of the interplay of events that are not readily apparent until conferences such as this one document our individual activities. It is important in gaining a mental view of what lies ahead to seek the common denominators of our collective activities. At the risk of being premature or grossly inaccurate we offer the following observations.

Resource management is not only a new term, it is an emerging discipline and technology. The field is now underwritten by the purer sciences (ecology, limnology, oceanography) and the applied sciences (wildlife biology, forestry, range management, landscape architecture). Its relationship with these disciplines will continue to grow and strengthen. This evolving relationship will produce a more tangible, creditable and higher order of resource management. Resource management is still perceived as a by-product of the sciences. Soon enough it will be a science unto itself.

Resource management as an emerging discipline is still in its formative stages. It is largely a conceptual entity that is given form and structure within our sociopolitical world through the vehicle of legislative regulation. Not enough time has elapsed to prove or disprove its worth in terms of our culture's value systems or time frames.

Resource management ultimately is an expression of social values. It is not possible to analyze all the values and interests of conflicting parties interacting in the resource management arena. It is, however, possible to look upon any arbitrated resolution to a resource conflict as an index of social responsibility to ourselves and our environment. As Lynton Caldwell observed (1971) ". . . . worsening conditions in the public environment and the growing science of ecology are inducing the popular comprehension necessary to political acceptability and may help formulate a system of ethics. . . . that will add emotional reinforcement to intellectual conviction. An ethics of man in relation to his environment is also an ethic of human relations."

Resource management as a discipline plays an integral part in our national welfare. The resource management process will become even more complex and critical within the regional, national and global context. Resource management decisions concerning wildlife and wildlife habitat will graduate in importance in direct proportion to our wants and needs for the total environment.

These observations were gleaned from our work with wetlands in the southwestern United States. They are neither new ideas nor substantiated facts. They certainly come as no surprise either. If they are to serve any useful purpose to this conference, they must be presented within the context of our work.

The National Wetlands Inventory and Classification System

The U.S. Fish and Wildlife Service (USFWS) has developed a new wetland classification system for the United States. This classification system, entitled *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin 1979), is being used in an inventory across the United States. Its structure is hierarchical with five systems, Marine, Estuarine, Riverine, Lacustrine and Palustrine at the highest level, and dominance types based on dominant plants or animals at the lowest level (Figure 1). With modification, this system could be incorporated into a generalized classification of all land types. This work improves upon earlier classification systems (Shaw and Fredine 1956, Martin et al. 1953) conducted by the U.S. Fish and Wildlife Service.

At the top of the hierarchy, wetlands and deep-water habitat areas are assigned to one of five ecological systems. General agreement on the definition of these systems is recognized. There are, however, inherent problems in putting artificial boundaries on natural continua. All these systems with the exception of the palustrine system are divided into subsystems. The subsystems represent accepted groupings, but their precise technical definition is not totally resolved.

Below the subsystem level, wetlands are assigned classes that should be separable without detailed measurements. Classes are divided into subclasses where a logical separation has traditionally been recognized, such as broad-leaved evergreen, needle-leaved evergreen, broad-leaved deciduous and needle-leaved deciduous forested wetlands.

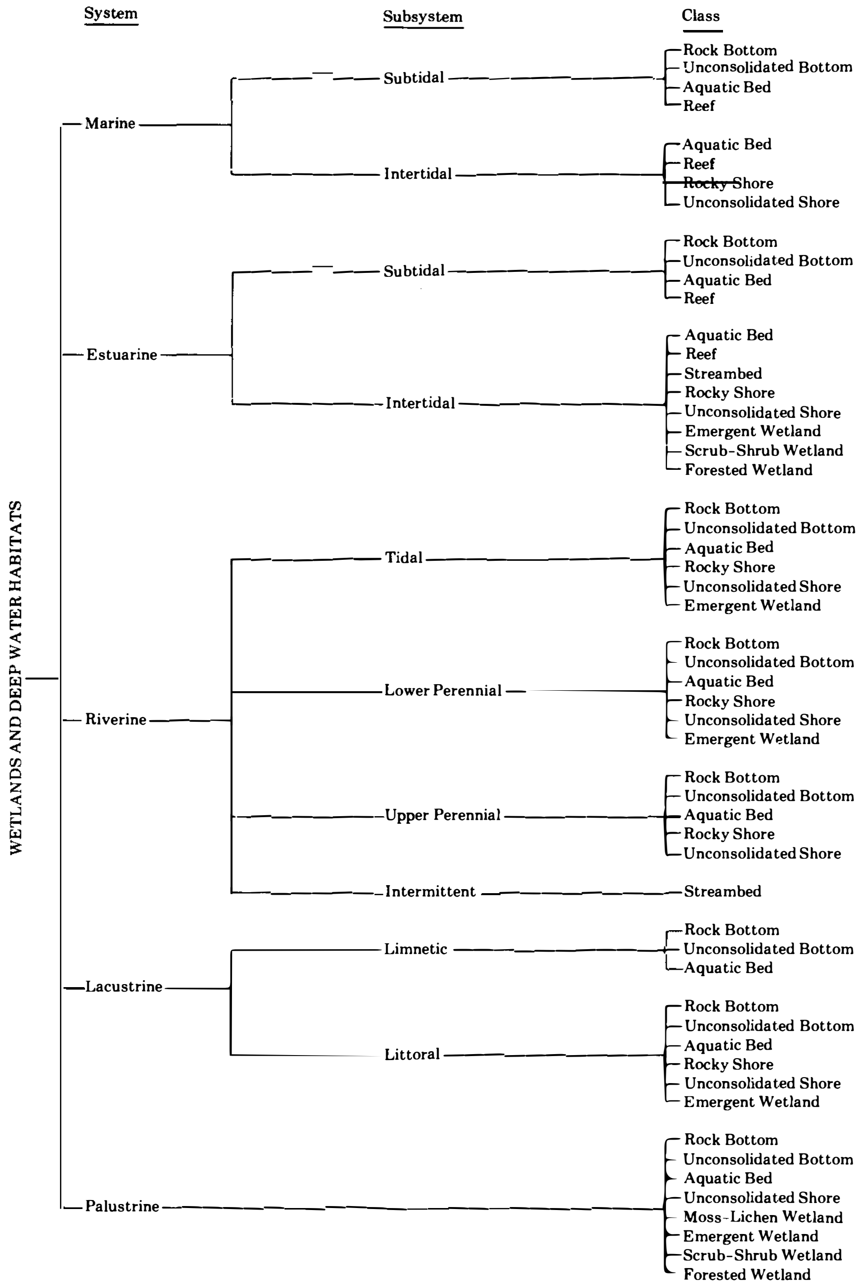

Figure 1. Classification hierarchy of wetlands and deepwater habitats, showing systems, subsystems and classes. The Palustrine System does not include deepwater habitats.

The classes or subclasses are divided into dominance types which form the most detailed level of the classification. These are based on the dominant plant or sedentary animal species and substrates of the wetland. Dominance types are particularly important because the dominant species, in conjunction with knowledge of the ecological region, are significant indicators of environmental parameters such as water quality, water regime or water chemistry. Additional detail according to Cowardin (1977) is furnished through the use of modifying terms which are either taken from existing classification systems or were developed and defined for this classification. A more detailed description of this classification system can be found in the final report (Cowardin et al. 1979).

The Products

There are five tangible products derived from this work. Together these products directly serve the needs of wildlife and wildlife habitat. The classification system, described above, tells the resource manager what is there. The inventory tells him where it is, how much there is and how it relates to similar pieces of resource information. The base maps provide a common reference for all resource managers to use. These maps help them visualize their place in the geographical and hierarchical structure common to all resource decisions.

The Base Maps

The final base maps were used in much of the preliminary work with the inventory process. There are 625 reproducible 1:250,000 scale Cronaflex maps inked and labeled with the appropriate "ecoregion" (Bailey 1976) and land-surface form boundaries and units (Hammond 1964). These maps are suitable for manual digitization for incorporation into the Land Use Data Analysis System (LUDA). These maps provided the Fish and Wildlife Service with: (1) small scale maps of the conterminous United States which illustrated the location of "ecoregion" and landform boundaries with respect to each 1:250,000 scale topographic sheet, (2) showed the geographic relationships among topographic sheets, and (3) identified each map sheet by name.

The Inventory Maps

The inventory maps come in three scales and two forms. Only one will be available for public purchase due to the high cost of reproduction. The final inventory maps are inked, labeled alphanumeric wetland and deep-water habitat types superimposed in color over a topographic base map (1:100,000 scale). Ecoregions and land-surface form boundaries and units are also superimposed on the inventory map. Cronaflex copies are kept on file at the National Wetlands Inventory Headquarters in St. Petersburg, Florida. Preliminary Cronaflex maps at 1:62,500 and 1:24,000 are also on file there. These 1:100,000 maps provide the user with: (1) a summary of the classification system, (2) cartographic data describing the map and its location within the state and the adjacent wetlands maps, and (3) the location and distributional characteristics of the wetlands and deep-water habitats of the area.

Statistical Summaries

Two kinds of statistical data are currently being produced to further quantify the wetlands maps. First, a statistical summary of wetland data by type within the state, county, ecoregion, land form, and hydrologic unit is provided. Second, a summary of wetland acreage by typed wetland for 1:100,000 scale, 15 or 7-and-one-half minute U.S. Geological Survey (USGS) quadrangle map is provided. This information is still being compiled for those wetland maps that are now completed. This supportive information lags behind map production due to the high costs in technological production and computation.

User Notes

A written summary is currently being compiled for each final 1:100,000 scale map. This summary (1) describes the mapping procedure and mapping conventions, (2) summarizes collateral data on specific hydrologic boundaries, land-surface forms, ecoregions and in some cases major landownership boundaries, (3) describes the dominant plant and animal species observed in the area, and (4) describes the dominant wetland and deep-water habitat types found in the area.

Application Problems in the Southwestern United States

There is difficulty in coming to a consensus as to what constitutes a wetland in the Southwest. There are several fundamental reasons for this. First, wetlands that do exist usually occur in the seams, crevices and canyons, and mountain meadows where few people travel. Our association with them is limited. We have a rather incomplete image of both their presence and their diversity. Second, wetlands do succumb to evaporation losses and low annual supplies of water. Their presence is interrupted giving them an intermittent character. We can easily perceive them as aberrations in nature. They are more accurately described as part of the continuing landscape process when viewed within the context of the cyclical wet-dry regime. Finally, there is the problem of definition. There is no universally acceptable ecological definition for wetlands. Wetlands are unique to the region in which they are formed. "Bogs," "rich fens," and "cienegas" are terms that describe the parochial characteristics of wetlands rather than the universal ones. Nevertheless, in order to better understand the wetland condition, a set of criteria need to be identified. These criteria are difficult to generalize. The distinction to be made between a wet and dry environment lies along a gradient. This gradient cannot always be directly measured nor easily perceived in the field. This is especially true in the arid environment. The gradient is interpreted from the natural components manifested within the environment as plant species differences, soil type differences and microclimatic variation. These components are not responsive to fluctuating conditions within the same time-space intervals as the actual water gradient. When this is true in an exaggerated sense such as in the Southwest, it becomes intellectually difficult for some people to even recognize that a wetland condition actually exists.

Despite these limitations a set of criteria and definitions were developed by the U.S. Fish and Wildlife Service for the purposes of inventory, evaluation and management of the wetland resource. Wetlands according to Cowardin et al. (1979)

are landscapes where " . . . saturation with water is the dominant factor determining the nature of soils development and the type of plant and animal communities living in the soil and on its surface."

The problem arises in the application of the classification system and in the mapping conventions. A disciplined rigid, inflexible adherence to the classification system and mapping conventions at the lowest level of mapping resolution has resulted in inclusion of areas that, under a preliminary, rational biological on-the-ground view, do not represent accepted wetland areas. Therefore, biologists might have little confidence in the overall inventories since within a site visit context there is little or no evidence to prove a wetland condition exists.

Wetlands must have one or more of the following three attributes: (1) at least periodically the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soils, or (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the year (Cowardin et al. 1979). To illustrate some application problems in the Southwest consider the various combinations of criteria.

Type I—No Soil, No Hydrophytes but Water Present

These conditions bring to mind a gravel beach or rocky shore. The most common wetland type found in the Southwest is R_4SB (Riverine Intermittent Streambed). Virtually every drainageway that is large enough to be detected from aerial photos and identified in the field to receive a significant flow of runoff during the year falls in this category. The problem is obvious. Technically such drainageways are classified as wetlands but used and perceived by natives as drylands. This is especially true the farther one travels away from the source of water into the drier region. Wildlife use these landscapes as travelways, shelter, and periodically as sources of food and water. Human users may totally disregard any water related use of these lands. They might therefore reject any environmental classification that does not perceive the area as they do.

A second example within this category is R_2OW (Riverine Lower Perennial Open Water). This wetland in a natural setting is a free-flowing water course free of vegetation. This designation might have a second interpretation in the Southwest. It may be man-made water course, an irrigation canal or even a subsidized river system. The substrate may not be a hydric soil or even a soil, but rather a concrete bed to prevent water loss. Cultural needs in an arid climate include water. Elaborate systems are created to support this need and man-influenced conditions that favor plants and wildlife are created as well. The presence of water provides the opportunity for life in the arid environment. Many times it is the only natural limiting factor. Our interpretations of this source of water make little difference to the cottonwood trees (*Populus* spp.), sycamore groves (*Platanus* spp.) or mesquite bosques (*Prosopis* spp.), nor do they prevent the herons, rails, ducks or sandhill cranes migrating through the arid regions from feeding on the ephemeral aquatics that are there.

Type II—Nonhydric Soils, Hydrophytes Present

These conditions might bring to mind the margins of an impoundment where hydrophytes have been established, but hydric soils have yet to be developed.

Consider the PFO type (Palustrine Forested). Tree canopy in the Southwest is typically comprised of small numbers of trees low in overall height scattered strategically in the topographic seams throughout the landscape. This is particularly true in the lower elevations where temperatures are high and water availability on the surface is low. Aerial photo evidence might indicate the concentration of water under these canopy patches. In the field these canopy patches prove to be sustained more by the ground water sources generated from this and other surface drainage areas. The trees may have gotten their start as seedlings transported to this spot by runoff and maintained for a time by surface water reserves. Eventually tap roots allowed them to survive their increased need for water by utilizing ground water reserves. Southwestern vegetation reflects the great variation in extremes at both the macroclimatic and microclimatic levels. Wildlife exploit these various landscapes at different times of the day, season and year as a way of fulfilling their basic needs for survival. Wetland types collectively reflect the nature of the environment's diversity and variety. They also reflect the degree of opportunity made available for wildlife survival in the Southwest.

The PEM type (Palustrine Emergent) existing on nonhydric soil illustrates another application problem. PEM in the arid or semi-arid landscape can be easily misinterpreted if the wet-dry cycle is not clearly understood. Solar incidence and cloud-free days make the Southwest one of the finest growing regions in the country given the presence of water. When conditions are right for plant growth the result can be phenomenal. Wetland biomass when viewed during leafout tends to mask the equally long periods of low productivity. One might miscalculate habitat potential, forage production or wildlife densities without reliable climatic data to support such judgments.

A final application problem is used to demonstrate problems of misinterpretation in the higher, moister mountain regions of the Southwest. Water supplies here are more likely to be permanent. Waterflow volumes and waterflow levels are influenced by snowmelt runoff and large scale weather systems such as coastal storms or hurricanes that travel inland into arid regions. When this happens the bottoms, banks and even the direction of a stream are rearranged in dramatic fashion. These wetland types R_2BB, R_3BB, R_2SB, R_3SB (Lower Perennial and Upper Perennial Beach/Bar, Lower Perennial and Upper Perennial Stream Bed) represent the formation of new and unstable landscapes formed by this phenomena. It starts with the power of erosional forces of flood waters and continues with the stabilizing forces of vegetative growth and soil development. All too soon these wetland landscapes may be rearranged, destroyed or transported further downstream with the occurrence of the next ten-year storm flood.

The natural regime creates and then destroys landscapes over a given period of time. Aerial photo evidence captures a fixed image of this process. This evidence must be supported by collateral data from other sources so as to validate any management or evaluation procedures based on this work. This is particularly true in the Southwest. Humans have not yet totally enveloped the environment they live in. There are vast spaces surrounding urban centers. Similarly there are enormous gaps in knowledge with respect to environmental functioning. It is difficult to properly manage that which is not totally understood. When working in the mountainous portions of the Southwest it becomes apparent that management know-how, if it is to be responsible, must be equal to the challenge in both complexity and scale. The NWI is based on photo evidence, collateral data and intellectual judgment. Each certainly has its limitations. The work is simply a reflection of the state of the art of resource management and an indication of how far it yet has to go.

The Importance of the National Wetlands Inventory to Wildlife Habitat Values

The future of wildlife and habitat that supports wildlife is linked to two important groups of people within our society. These are the landowners and the land managers. Their perceptions, understanding and decisions will ultimately influence the critical factors controlling wildlife and wildlife habitat. The National Wetlands Inventory (NWI) can significantly add to the information base used to make such decisions. First, consider the land ownership picture in the Southwest. For the purposes of this discussion the Southwest shall include all of Arizona, New Mexico, Oklahoma, parts of Texas, Colorado, Nevada and California.

A significant proportion of the land is owned by the public and managed by federal agencies. Generally speaking there are two kinds of lands: the highly productive forest lands, wetlands and rangelands and the moderate to poorly productive arid rangelands. Together these land parcels make up an enormous tract of Southwest habitat. Much of this public land is managed under multiple-use policies set forth under federal regulation. Three of these federal agencies (Bureau of Land Management, U.S. Forest Service and the U.S. Fish and Wildlife Service) have a tradition of managing for the improvement of wildlife and wildlife habitat. It is safe to speculate that wildlife and wildlife habitat values will be very much influenced by the policies and programs these three agencies are able to promote and coordinate with the various state programs in the region.

These public lands are experiencing an increased demand for various uses from a growing population base (Table 1).

This condition, herein portrayed for U.S. Fish and Wildlife Service Region 2, is typical in Nevada and parts of California and Colorado as well. These vast tracts of habitat are entering a new era of development. Many of these federal lands will be subjected to new levels of competitive demands for recreation space, wilderness areas, water needs and forage and timber for human purposes. Wildlife and wildlife habitat will undoubtedly suffer as a result.

The National Wetlands Inventory will enable land managers to accommodate reasonable multiple-use demands by the public in several important ways. First, priorities must be set as to where and why the trade-offs will be made. Even reasonable demands can negatively impact wildlife and habitat. The inventory can locate critical reproduction areas, wintering grounds and watering and forage areas

Table 1. Region 2—United States Fish and Wildlife Service.

State	1980 population	1970 population	Percent change	Area (square miles)	People per square mile
Arizona	2,717,866	1,775,399	53% +	113,909	23.85
New Mexico	1,299,968	1,017,055	28% +	121,511	10.69
Oklahoma	3,025,266	2,559,463	18% +	69,920	43.26
Texas	14,228,383	11,198,655	27% +	267,339	53.27

for wildlife within a given study area. Coordinated planning at this point can avoid exclusionary land use decisions that destroy wildlife habitat. Second, the inventory can give the land manager a clearer picture of those critical habitat values that exist in the region. All habitats and resources cannot be saved given the pressures of conflicting uses between wildlife, wildlife habitat and human use demands. The land manager must develop a best case and worse case strategy so as to protect those irreplaceable habitat areas. Finally, the inventory gives critical pieces of data to the people who will likely come into conflict early enough in the planning process so that negative impacts can be avoided. There never is a complete set of data available to make a totally sound decision with respect to resource use and allocation questions. The NWI locates one of the most critical habitat types in the arid Southwest—the wetland. Ecologically, wetlands are premier performers. Their value to wildlife, plant life and humans is incontestable. It is imperative that any decision influencing wildlife and wildlife habitat include an understanding of the wetland condition in the region.

Consider the land management situation in the Southwest. The Bureau of Land Management, the U.S. Forest Service and the U.S. Fish and Wildlife Service have already taken steps to insure that wetlands are considered in any and all land use planning questions. The BLM released a document entitled, *Wetland-Riparian Area Protection and Management* (U.S. Bureau of Land Management 1979) which establishes bureau policy and procedures to identify, protect, manage and enhance wetland and riparian areas on BLM administered lands. The document spells out the responsibility each of its staff levels has with respect to: (1) protection and enhancement activities, (2) habitat management activities, and (3) development, construction and maintenance activities. This document represents a coordinated second step towards the continued maintenance and protection of wildlife in the Southwest through the vehicle of habitat management. The NWI can contribute to its sister agency's needs by minimizing resource inventory duplication and where applicable enhance any data collection the BLM does carry out. This kind of data sharing is made possible by the methodology and hierarchical concepts used in designing the national wetlands inventory and classification system.

The U.S. Forest Service has acted in a similarly responsible fashion with respect to wetland-riparian habitats. Two levels of response within the State of Arizona will serve to illustrate. The Rocky Mountain Forest and Range Experiment Station periodically revises its five-year research plans. The wildlife habitat research unit located in Tempe, Arizona, identified 13 potential problem areas. Heading the list of problems identified were: (1) riparian ecology questions, (2) livestock and wildlife interactions, (3) threatened and endangered species, and (4) systems for managing wildlife habitat.

Similarly the national forests within Arizona (Apache-Sitgreaves, 2 million acres (0.81 million ha); Coconino, 1.8 million acres (0.73 million ha); Kaibab, 1.7 million acres (0.69 million ha); Prescott, 1.2 million acres (0.49 million ha); and Tonto, 3 million acres (1.2 million ha)) are committed to the protection and management of the water, land and wildlife resources. The average budget allocations for land management (6.8 percent, 2–16 percent range), water management (2 percent, 1–3 percent range), and wildlife resources (2.2 percent, 1–4 percent range) on these forests indicate that actual financial commitment is still very low (U.S. Forest Service 1980).

In each situation the Forest Service has complied with federal regulations mandating the formation of management and protection activities concerning habitat and wildlife values. Both the forests and the experiment station are hindered in implementing serious levels of activity by financial and manpower limitations. Budget constraints and inflation are real problems. They translate down to the land manager in very real terms. The NWI was developed in the midst of such conditions and designed to alleviate some of these problems. First, the system, by virtue of its mapping scale and hierarchical structure, expedites the transfer of habitat information to any other similar inventory. The system is open-ended so as to accept new elements or modifiers as knowledge advances. Second, the system has a permanent building block or unit that is identifiable to the lay public on the ground and through remote sensing. To be effective this unit must have a high degree of permanence. The wetland is an indicator of relative permanence with respect to climate, topography, soil and solar incidence of any given area. The Forest Service can realize great gains in the area of wildlife, water and land management activities in Arizona with less than anticipated expenditures by assimilating the data acquired from the NWI into their current planning procedures.

The U.S. Fish and Wildlife Service has identified two programs of top priority during 1980. These are the migratory bird program (MBP) and the mammal and non-migratory bird program (MNBP). The NWI can significantly contribute to the success of each of these programs in the Southwest. Consider the migratory bird program. A fundamental assumption of this program rests on the belief that an unsatisfied demand exists for migratory birds. There is the belief that the public wants present numbers of most species to be maintained or increased. Furthermore, the USFWS believes that populations cannot be increased beyond the carrying capacity of their habitats. Maintaining populations at present levels or increased to some degree can only be realized with a clear understanding of habitat condition. In this regard it is imperative that the amplitude of habitat variation, the frequency of precipitation and the duration of wetland condition be clearly understood. Separate studies to determine the exact nature of this fluctuating condition are extremely costly. The NWI serves as an integrator of environmental responses. It delivers a static image of what habitat there is and where and how much of it is available for wildlife. This information allows the Southwest land manager to concentrate efforts on resource evaluation and protection matters. These data appreciably advance the USFWS capability to manage its own wildlife refuges in response to local and regional environmental variations influencing the migratory wildlife coming from remote corners of the national and international flyway.

Finally, consider the mammal and nonmigratory bird program. This program encompasses all wildlife except the fin-fishery resource, migratory birds and endangered and threatened species. The program is responsible for mammals, nonmigratory birds, reptiles, amphibians, crustaceans and terrestrial mollusks. Most of the species are considered resident wildlife and are primarily under the jurisdiction and management of the states. This program is extremely ambitious. It provides partial funding for several operational entities of the service including the national wildlife refuge system, wildlife research, management activities and extension education.

These species and their supporting ecosystems are given ever-decreasing amounts of dollar and work force support each year. It becomes necessary each year to protect and conserve those fish and wildlife resources of greatest importance and concern to the nation. The USFWS defines those fish and wildlife resources with significant problems in specific geographic areas. The objective here is to protect, restore and enhance wildlife habitat of greatest importance by focusing manpower and dollars on areas of critical concern. In the Southwest water is a limiting factor for survival for a major portion of the wildlife population. Logic dictates that wetlands and aquatic habitats in the Southwest be given a high priority so as to gain the best efficiency in program capability with respect to wildlife species and habitat protection. The NWI is critical to the successful performance of this program here in the Southwest.

Conclusions—Resource Management for the Eighties

Future trends for resource management are strongly influenced by the past. There is a sequence of events which taken collectively make up the resource situation at any given time. The era 1969-1981 was a time when broadly conceived resource policy objectives yielded more purposeful policies, which in turn influenced the flow of events. The eighties look to be a time when the reverse may be true. Events such as increased energy costs, water supply problems and an expanding population will shape future events which in turn may lead to the restatement of policy.

Resource management and particularly wildlife and wildlife habitat management have undergone significant changes over the past twelve years. Three particular kinds of change have taken place. First, land management as practiced by the federal agencies has become more directly involved in the protection and enhancement of environmental values that sustain wildlife and wildlife habitat. We have evolved from a mentality of single-use or separate-use resource management to one of multiple-use management on the public lands. To a degree the multiple-use management concept is feasible, but in order for it to work there must be an associated change in the definition of resource for competitive users. Multiple-use makes possible the coexistence of competitive users only if the definition of the quantity and quality of use changes. Presently, wildlife and wildlife habitat play a role in most planning considerations on federal lands.

A second major change experienced over this period has been the technological applications developed to deal with resource management questions. Remote sensing, telemetry, computer and word processing technology have combined with changes in operational concepts to upgrade our ability to understand the wildlife resource. The NWI is just one example. Technological advances do little in and of themselves to solve resource management questions. These questions are very much related to culture, economics and political power. Technology more than anything else reveals to us the consequences of our decisions and the related environmental costs we incur from them.

The most significant change was realized in the population itself. People are basically motivated by the same needs. It was in the expression of those desires that change was realized. For now, people in the Southwest tend to value wildlife and wildlife habitat. They, like many people throughout the United States, have found a place for wildlife in their beliefs and systems of values.

But what about the future of wildlife and wildlife habitat?

Throughout this discussion we have emphasized wildlife and habitat manage-

Table 2. Land ownership in the United States.

	Billions of Acres
Total United States land	2.3
60 percent owned by individuals & corporations	1.38
40 percent owned by federal, state and local governments	.92
Of the 60 percent owned privately	1.38
95 percent is in ranch and farm land	1.31
2 percent is used for dwellings owned by 50 million people	.0276
3 percent is used for commercial, industrial or recreation purposes	.0404

ment on the public lands. We have done so for two reasons. The most significant gains for wildlife and habitat have been realized on these lands. Secondly, these lands constitute the single largest parcel of land managed by one consolidated authority—the federal government. The proportional distribution of land ownership in the United States suggests a limited number of options left open for wildlife (Table 2). It is highly unlikely that wildlife habitat will be improved within the private sector. Public lands will be severely challenged by separate use and exclusionary use proposals. It is essential that wildlife policy and programs continue to protect and manage those parts of the environment critical to wildlife survival. This must be accomplished with the ecosystem perspective in mind at the regional, state and local level. Economic and political realities will force us as a nation to redefine the resource base once again. The wildlife and wildlife habitat resources have been culturally defined and attributed a value that is associated with our quality of life. This is not likely to change. What is definitely going to change is the context in which wildlife and wildlife habitat management is played. The role of resource managers as people concerned with wildlife is to move management into a position where the resources to deal with these problems have been realized.

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Industry's Approach to Personnel Classifications, Training and Performance

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The Xerox Compensation policy simply stated is: "Xerox intends to pay wages and salaries as good as, or better than, those paid by other progressive companies for equivalent work. Xerox also intends to recognize and reward superior performance fairly and generously." Xerox wage and salary programs are geared to two things: (1) the goals and needs of our business and (2) the goals and needs of our people. Xerox believes the two categories of goals and needs are interdependent.

Salaries and related costs are our largest single operating expense. The profitability and success of Xerox depend on how well salaries relate to the productivity of our people. You as a manager are an employee working for a salary. You are well aware of how your salary relates to your productivity—which is the productivity of your organization. You are equally aware that your salary—the price of your services—is not only a statement of the current value of your services, but also the main determinant of your family's standard of living. Your people are aware of these things too. They see their compensation not only as an objective measurement of the value their work contributes, but also as the basis of their living standards.

So it is vital, to be effective as a manager, that your people understand the process used to ensure the equity of their compensation. This process at Xerox is known as Salary Administration. It is intended to:

1. Relate salary ranges to the skill and responsibility demanded by the position;
2. Relate Xerox salary ranges to salaries paid for comparable positions in other companies in order to keep Xerox in a strong competitive position for attracting productive people;
3. Give managers the tools for planning and controlling salary-increase expenses; and
4. Give line managers the tools—and the guidance—to ensure that Xerox people are properly paid.

Xerox wants to make its compensation process an open book, so that all its people understand and accept its policies and procedures. Xerox managers find that this understanding and acceptance will be greatest when they are as clear and explicit as possible in explaining the process to their people. We should tell them: their salary range—minimum, midpoint, and maximum—and the implications of their salary level within that range; when they are eligible for performance review and salary increase; Merit Increase Guidechart percentages; contents of their Position Questionnaires—which, ideally, they prepared themselves subject to review and approval; their overall appraisal and detailed comments; and how the amount of their increase was determined.

Remember that this is their work, their career prospects, their livelihood we're talking about. They are entitled, and they know they're entitled, to full and frank disclosure on our part. In some instances, where the appraisal is critical, and the merit increase small or nonexistent, we may find the conversation painful. But the worst disservice you can do your people is to withhold your constructive criticism. You owe it to them. Full disclosure includes the bad news as well as the good news. On the other hand, full disclosure does not extend to discussion of what is not in the employee's proper business. Employees have *no* right to know the salaries of other employees or the appraisal ratings and content of other employee's performance reviews.

Within the framework of the policies, practices, and techniques used at Xerox, managers are basically responsible for pay decisions affecting their people. The aggregate quality of all our managers' decisions is the heart of the Xerox Salary Administration program. The guidelines and procedures we set may help, but they do not do the manager's job. The manager does that.

Xerox has six different salary programs in U.S. Operations: Exempt-Non-Selling, Non-Exempt, Technical Representative, Customer Engineer, Sales, and Hourly.

A. Exempt or Non-Exempt Status

Before dealing specifically with the different salary programs, it is worthwhile understanding what determines whether a specific position is exempt or non-exempt. All Xerox employees, unless specifically exempted, are covered by the Fair Labor Standards Act (FLSA), which among other provisions, sets minimum wages and regulates overtime pay. Thus, the terminology "Exempt" and "Non-Exempt" is not an invention of Xerox wage and salary administrators. It is legal wording set forth by the United States Government, to indicate whether an employee is or is not exempted from the provisions of the FLSA. Employees often wonder why a given job is classified exempt or non-exempt. The primary reasons for exemption are high-level administrative duties, executive duties (supervision), professional duties (lawyers, engineers, etc.) and the duties of outside salesmen.

The burden of proof is on a corporation to prove that its positions are exempt and thus not covered by the Fair Labor Standards Act. Non-exempt status is protection for the employee, since it requires overtime payment for all work in excess of eights hours a day or 40 hours a week.

B. Examples of Non-Exempt and Exempt Positions

Engineering Aides, Secretaries, Procurement Expediters, Customer Assistants, Data Control Clerks, and Technical Representatives are usually classified as non-exempt under the FLSA. Supervisors, Foremen, Managers, Analysts, Engineers, Employment Recruiters, and Accountants are usually classified as exempt under the FLSA.

C. Hours of Work (Protection for the Employee)

It is important to note that the majority of our non-exempt employees are paid for a 40-hour week which consists of five, eight-hour days, Monday through Friday. If a non-exempt employee works more than eight hours in a day and/or over 40 hours in a week, it must be noted on the time card, and paid at the appropriate overtime rate. These regulations are provisions of the FLSA and the Walsh-Healey Act. Saturdays and Sundays are paid at time and one-half and double time, respectively.

D. Penalties

The FLSA Administrator conducts routine investigations in addition to responding to specific complaints. Companies not complying with the FLSA are subject to civil and criminal proceedings involving fines, imprisonment, double payment of wages due, and court costs, as well as very close future scrutiny through "routine" investigations and adverse publicity.

Job Evaluation

The basic purpose of job evaluation is to establish equitable internal pay relationships. In other words, job evaluation is a measurement of job duties against a predetermined yardstick in order to assess relative job worth. Thus the process is impersonal and has nothing to do with how well the work is performed or the ability, potential, or attitudes of employees. Job evaluation measures job worth in an administrative rather than an economic sense. Economic worth can be determined only by the natural forces of supply and demand in the labor market. The administrative concept of job worth involves importance and difficulty.

A. Non-Exempt Job Evaluation Factors

Non-exempt jobs are rated on a 10 factor scale. These factors are:

1. Education level or equivalent;
2. Experience and background required to begin on the job;
3. Complexity and scope of the duties performed;
4. Contact with others inside Xerox;
5. Contact with others outside Xerox;
6. Accountability for errors;
7. Guidance of others in performing their duties;
8. Level of confidential information available to the incumbent;
9. Work surroundings; and
10. Physical effort required.

Each factor is assigned a numerical point score. The total number of points given to a job corresponds to a salary grade which, in turn, has a salary range assigned to it. There are 14 non-exempt salary grades.

B. Exempt Evaluation Factors

Xerox uses the Hay Evaluation System for exempt positions. Under the Hay System,[1] exempt positions are evaluated according to the following three factors:

1. Know-How—the sum total of skills, however acquired, required for acceptable job performance. The sum total which comprises the overall fund of knowledge has three dimensions:
   a. Practical procedures, specialized techniques, and learned disciplines.
   b. Ability to integrate and harmonize the diversified functions involved in managerial situations. This may be done consultatively as well as managerially, and may involve in some combination the areas of organizing, planning, executing, controlling, and evaluating.

[1]Developed by Edward N. Hay Associates, Philadelphia, Pennsylvania

c. Active practicing skills in the area of human relations.

2. Problem Solving— The original, "self-starting" thinking required by the job for analyzing, evaluating, creating, reasoning, and reaching conclusions. Problem Solving has two dimensions:
   a. The environment in which the thinking takes place.
   b. The challenge presented by the thinking to be done.
3. Accountability—Answerability for action and for the consequences thereof. It is the measured effect of the job on end results. It has three dimensions in the following order of importance.
   a. Freedom to act—the degree of personal freedom or procedural control and guidance which affect the position.
   b. Job impact on end results.
   c. Magnitude—as indicated by the general dollar size of the area most clearly or primarily affected by the job on an annual basis.

Each of the three factors is assigned Hay Points. The total of the Hay Points translates to a fixed midpoint dollar value with an established minimum and maximum.

Salary Surveys

After job evaluation has established the relative ranking of jobs within Xerox, the next step is to ensure that our related pay ranges are competitive with other progressive companies. To accomplish this, each year a comprehensive study is made of all salary programs. Xerox participates in and initiates a variety of salary surveys, each tailored to the relevant employee group.

In reviewing our salary programs we compare Xerox salaries with those paid by other progressive companies for equivalent work in terms of salary ranges and actual salaries.

A. Exempt Salary Surveys

Exempt salary comparisons are made primarily on a nationwide basis. Since these employees are hired from a national labor market, and since they are a much more mobile population, we must ensure that both salary ranges and actual salaries are competitive on a national basis. Some of the exempt annual surveys we participate in are: American Management Association (AMA); Edward N. Hay Associates' (a consulting firm in Philadelphia, Pa.) Exempt Salary Survey and Field Sales Compensation Study; and Project 777 (a major national executive compensation survey).

In addition, Xerox conducts its own salary surveys and exchanges data directly with other progressive companies such as: Kodak, ITT, IBM, Bell Laboratories, General Electric, RCA, and DuPont. In either the individual exchanges or general salary surveys, direct job for job comparisons are made whenever necessary. Precautions are also taken to ensure that comparisons are being made to the most progressive companies in America, not to general industry as can be reflected in typical salary surveys.

B. Non-Exempt Salary Surveys

Non-Exempt and Technical Representative employees are hired generally from a local labor market. That is why area differentials have been established for this group of employees. We examine how our salaries compare on a national basis, but more importantly, we concentrate on how we compare on a local basis. Briefly, we consider:

1. Local wage rates in each area where Xerox does business.
2. Living costs in each area.

In the majority of Xerox locations, the Bureau of Labor Statistics conducts salary surveys for numerous skills and types of positions. Our non-exempt positions are then compared to approximately equivalent positions in these surveys to evaluate the adequacy of both salary ranges and actual salaries. To further ensure that we are comparing salary-range midpoints and actual salaries to the more progressive companies in each location, we compare to the top one quarter (75th percentile) from the BLS and not to the averages.

We do not stop at this. The BLS data is then cross-validated with similar data published by the American Management Association. If there are remaining questions or concerns, Xerox will, if necessary, conduct its own local salary surveys. If discrepancies exist, Xerox will rule in favor of the higher salary information.

Performance Appraisal and Feedback

The second half of our compensation philosophy statement indicates that, "We also intend to recognize and reward superior performance fairly and generously." To support this statement, Xerox has developed a pay-for-performance review system. The primary purpose of this system is to help the manager arrive at a fair decision concerning pay, and to communicate that pay decision in a rational way. We will consider the Performance Appraisal system in two phases: Phase I—Standards of Performance and Phase II—Feedback of the Appraisal.

A. Phase I—Writing the Appraisal

The appraisal write-up should be seen as a roadmap for the feedback session. If the map is clear and well prepared, the session has a good chance of going well. If the write-up is unclear or inconsistent, it may cause problems even if the rating itself is seen as fair. There are four basic rules to keep in mind:

1. Describe favorable results in terms of standards. Don't merely say, "Mary did a fine job." Say: "Mary's careful planning and skillful dealing with technical problems enabled her to exceed her target date by three weeks."
2. Explain both praise and criticism. Don't say "Nancy's planning was excellent, but . . . " and then follow with 40 words carefully explaining your criticism. Support both praise and criticism with standards-oriented descriptive statements.
3. Avoid personal criticism. Don't say, "John was overly aggressive," say: "John's eagerness to accomplish results showed little concern for the feelings of other groups. Their resentment led to foot-dragging which contributed to missed target dates." Note that behavior and its consequences are described. Behavior objectionable to you is irrelevant to the appraisal if it had no adverse impact on results.
4. Avoid written advice. Don't say, "John must learn to work more harmoniously with others." Save this well-meant fatherly advice for another occasion, if you want it to be heard.

The reasoning behind these rules is to keep your write-up on a results-oriented track and to reduce the likelihood of the subordinate becoming so resentful of criticism that he or she does not hear it.

B. Phase II—Feedback of the Appraisal

The appraisal and feedback process is one about which there are mixed feelings. Companies and individual managers are torn on the issue of appraisal. On the one hand, they recognize the need to rate people's performance and to relate salary rewards to such ratings. On the other hand, they recognize that it is impossible to be completely objective in rating another human being, no matter what rating system is used, and that when one individual communicates a judgment of another individual, there is a high probability of some conflict or difference of opinion.

The task of the manager is to minimize this conflict by:

1. Limiting the goals of the appraisal session;
2. Minimizing surprises in the appraisal; and
3. Communicating the appraisal with skill.

Let's look at these objectives individually, and see what might be done to increase the probability of constructive appraisal outcomes.

1. Limiting the goals of the appraisal session

Appraising performance for salary purposes and counseling for performance improvement are conflicting goals. This statement, which challenges a good deal of conventional wisdom, is based upon a respectable body of evidence. In brief, the data[2] clearly shows that:

a. Comprehensive (dual-purpose) annual performance appraisals are of questionable value because the "judge" role of the manager gets in the way of the "helper" role.
b. An employee is more likely to feel reprimanded than praised as a result of an appraisal feedback. An individual will accept praise, but challenge criticism.
c. Criticism will be accepted only in very limited amounts.
d. Praise in one area will not make the employee more receptive to criticism in another.

Further, regarding performance improvement:

a. Little or no performance improvement results from "constructive criticism" received in appraisals.
b. Coaching should be a day-to-day, not a once-a-year activity.
c. Mutual goal-setting, not criticism, should be used to improve performance.

Traditional appraisal thinking is that an employee needs only a wise and perceptive manager to point out areas of needed improvement. However, this thinking ignores or minimizes the employee's need to maintain self-respect. People tend to do their job in ways that make sense to them and that they believe to be expected. The typical adult's response to criticism—constructive or otherwise—is to explain, justify, and defend his or her actions; not to listen, reflect, and problem-solve. It is ironic that the greater the need to improve performance (and, therefore, the

[2] Based on a three-year study done at General Electric.

more frequent and basic the criticism) the lower the chances of getting needed improvement from an appraisal. Recognizing the fallacy of dual-purpose appraisals, Xerox has urged that managers confine the first appraisal session to communicating appraisal of performance. Salary action taken is communicated at a later session and the two are then related. However, employees may request—and most managers want to give—suggestions for improvement of performance. So coaching often gets built into, or added onto, the appraisal. We urge you to do performance improvement planning and coaching at a separate, later time. One major obstacle is cleared if the first and second appraisals are limited to feedback of past performance and of salary action taken. The employee should be told that coaching for improvement will be done later, and a definite time arranged (within the next few days).

2. *Minimizing surprises in the appraisal*

This is the second factor influencing the outcome of an appraisal session. If the manager is doing a good job of keeping the employee informed, the appraisal should merely be a formalized documentation of what each already knows; yet rare indeed is the feedback session with no surprises. Why? Here are some basic reasons:

1. Not many managers feel comfortable in giving feedback. Rather than risk upsetting their people, they overlook or underplay deficient performance.
2. Busy managers tend to manage feedback by exception ("If I don't say anything, they must know I think they are doing O.K.").
3. A supporting system (such as target review sessions) may be lacking.
4. There may be a temptation to save up criticisms for the annual performance review—then to "unload."

The only way to ensure that you and your subordinate are in agreement on specific goals is to communicate clearly on:

1. Standards of performance you expect the individual to meet.
2. Progress and problems along the way.

These activities are so basic to good management—let alone sound appraisal practices—that we shall look at them in some depth.

Standards of Performance—A standard of performance is an agreement, ahead of time, between the subordinate and the manager as to how the employee will know when he or she is performing acceptably. Let's look at these things one at a time.

An Agreement—Standards should be resolved jointly based upon a common understanding of what is necessary and what is feasible. Standards handed down from on high may cause resentment if the manager does not express a willingness to discuss their appropriateness with the subordinate.

Ahead of Time—Standards are definitions of what will constitute acceptable performance. If they are not agreed upon in advance, they serve only as reasonable sounding second-guessing. They, therefore, require a general plan of action for achieving the goal or target. They may be vulnerable to changing requirements and unanticipated events.

How the Employee Will Know—This implies that the definition of standards or conditions is clear and available to the individual. The necessary feedback must be provided. This requires periodic progress review sessions.

When the Employee is Performing Acceptably—If this sounds like a modest achievement, it's meant to be. When you and your subordinate have been setting performance standards for some time, you can begin to worry about defining expectations for normal and outstanding performance. But that requires much more sophistication that most of us have. If you work with the individual on four to six key indicators of acceptable performance—and spell these out clearly—you will be well along.

3. Communicating the Appraisal with Skill

This third objective is made more manageable to the extent that you have met the first two. If the employee clearly understands that the purpose of the session is to communicate an appraisal, and if such official communication is in fact a summing-up of what you have previously discussed in work planning and oral review sessions, then the task of skillful appraisal communication is manageable. However, if the employee gets constructive criticism, advice, and counseling (along with some surprise evaluations) the chances for a meaningful communication are slim.

Appraisal feedback skills pay off apart from getting your evaluation across. A related study at G.E. found that manager skill in feeding back salary appraisals was highly correlated with favorable employee attitude towards a pay-for-performance salary plan. Here are the primary skills you will need in feeding back the appraisal:

1. Keeping the discussion on the track and moving;
2. Sticking to your original justification for your rating;
3. Listening to the employee's questions and comments with understanding; and
4. Giving out criticism in small doses.

One cannot acquire feedback skills by reading about them. Therefore, we will attempt only to explain what is meant by each.

Stay on the Track

a. Don't let an employee's challenge of your appraisal back you into coaching and advice giving.
b. If the employee genuinely wants coaching, outline the broad areas, but don't go into details. Remember, you're going to do coaching later.
c. Don't try to soften criticism by telling the employee of your high personal regard, hopes for his or her future, etc. This will only draw you into coaching and may give the employee the impression that you're really rating personality.

Stick to Your Original Justification

a. The heart of your justification should be written on the appraisal and should be based on standards, not on hip-shot judgments.
b. If your facts are right, and your judgment is sound—stick to it. Amplify, as necessary, your basic line of reasoning, but don't reach for a totally new basis. This only complicates things, and may undermine your basic argument. If, however, you find that your facts were wrong or incomplete—and it makes a difference in the activity rating—you should correct the appraisal.

c. Don't expect the employee to agree with you—only to understand your reasoning.

Listen to the Employee's Questions

a. Let the employee talk freely.
b. Paraphrase the employee's comments to be sure it is clear that you understand and respect them.
c. Recognize that the employee may be using questions to challenge your rating rather than to seek new information.

Give out Criticism in Small Doses

a. Make sure that any criticism is of behavior that affected results, not of personal traits.
b. Describe the specific situation in which the behavior occurred and its effect on results.
c. Don't expect the employee to "hear" and accept more than a total of three criticisms.
d. Don't expect praise to make criticism more palatable.

Summary

1. In preparing the appraisal, base your judgment of performance on results achieved in relation to reasonable standards, preferably worked out in advance with the employee.
2. Write the appraisal as descriptively as possible so that your appraisal cites the facts to support your judgment.
3. Effective feedback of an appraisal requires: recognition that coaching for performance improvement is seldom effective in a salary-oriented appraisal setting; minimizing surprises through clearly understood and jointly accepted standards; and communication practices which keep the discussion on track and limit the amount of criticism.

"Unless individuals accept the validity of performance appraisals and unless they know what kind of performance the organization requires and accepts, obtaining motivation is impossible." (Belcher)

Merit Increases Planning

Xerox as a matter of policy is a merit pay company. All salary increases for Exempt and Non-Exempt employees are earned and awarded on the basis of performance. The size and frequency of merit increases will vary depending on the employee's level of performance and position of current salary within the salary range.

A salary range is divided into two parts—the amount below midpoint and the amount above midpoint. The midpoint is established so that it is equal to or better than the average of salaries paid by the progressive companies with whom we compare data. The portion of the range below midpoint is to allow for salary growth as an employee becomes more proficient at his or her assigned task. The portion of the salary range above midpoint is designed to "reward superior performance fairly and generously" and represents salary payment well ahead of competititve average salaries for equivalent work.

The midpoint of a salary range then serves as a control point for determining actual salaries within a given salary range. In general, we expect the average salaries paid to a particular position to be close to the salary range midpoint of the position. All of our Merit Increase Guidecharts have been designed to achieve that particular goal.

The "pay for performance" philosophy relies on performance appraisals and merit increase guidecharts. The guidecharts are utilized to relate differing levels of performance, as measured through a formal performance appraisal system, to specific merit increases. The Merit Increase Guidecharts are divided into quartiles. The purpose of the quartile guidechart is to improve the distribution of merit increase dollars consistent with Xerox policy of midpoint control. The quartile guidechart will accomplish this objective by giving a greater merit percent for the same level of performance to those employees who are farthest below their midpoint. Employees at or above their salary range midpoint are being well paid, above the average for similar jobs in other progressive companies. Therefore, larger increases are given to those below their midpoint.

The performance dimension is sometimes diminished, on the basis that an employee whose performance is rated higher may receive an increase only a couple of percentage points larger than the next lower performance level. Although the difference may appear to be small in the first year, it adds up to very substantial amounts when compounded over a series of years. The few extra percentage points received by the better performer can add up over a period of time to salary increases twice as large on average, exclusive of promotions.

In American industry there are a variety of plans for distributing salary increases. None of them is universally accepted, and all of them have various shortcomings. Merit Increase Planning is far from perfect, but in Xerox' opinion, it is the most effective of the available alternatives. The Merit Increase Planning Program was introduced in early 1970. Prior to the MIP program, there was the absence of before-the-fact planning of merit increases. Analyses showed that there was insufficient discrimination between levels of performance and salary increases within and between departments. Considering that the salaries and related costs represent the largest single factor impacting revenues, there was a need to ensure that salary increases were maintained with an approved spending level.

The MIP Program, then, has three basic objectives:

1. Assure equitable distribution of merit funds between organizations;
2. Provide a more equitable distribution of merit increases between employees because managers have the opportunity to discriminate between exceeded, expected and low performance, in addition to looking at the salary relationships of their employees at the beginning of the year and at the end of the year; and
3. Provide Xerox with an effective salary cost control since the full year impact of merit increases can be evaluated before they are granted. The significant point to remember is that merit increase planning is a cost control; it is not a cost savings method.

Recognizing that in forecasting future merit increase plans, some plans may vary somewhat throughout the year. Changes are permitted to Merit Increase Plans. *These changes, however; must yield zero variance from the original plan at the Departmental level at year-end.*

The Senior Executive Service

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The Senior Executive Service (SES) is the personnel system for most of the men and women who administer programs at the top levels of the Federal Government. It was established on July 13, 1979, and covers most positions in the executive branch which were formerly classifiable as GS-16, 17 and 18, and Executive Levels IV and V. It also covers most equivalents of these positions except those requiring Senate confirmation. There are now approximately 7,200 SES members.

The system for managing executive personnel which existed before SES was not a system at all in the sense of being a coherent, carefully designed whole. It was, in fact, a disorderly hodge-podge of laws, rules, and regulations assembled bit by bit over a generation. The Civil Service Commission, which managed the pre-SES system, spent nearly a decade collecting information on the problems with the old system and devising a new system which would alleviate them. The Office of Personnel Management took this ground work, refined it via consultations with informed individuals and groups, and designed a new and rational system—the SES. Among the more serious problems the SES was designed to address were:

1. Fragmented multiple systems for managing what amounts to less than one-half of 1 percent of the Federal civilian work force.
2. Executive resources unrelated to the actual program needs of agencies.
3. A relationship between career and noncareer executives which relegated most careerists to positions of lesser responsibility and thus siphoned the most able career executives out of the Federal service.
4. An irrational compensation scheme, which placed compensation almost entirely in the automatic category, permitting little discretion on the part of management and generally leaving individual executives helpless to influence their own compensation.
5. A virtually nonexistent system of preparing able employees to assume management responsibilities, which fostered "old boy" networks and forced many executives to have to pick up management skills catch-as-catch-can after they were in executive positions.

Under the SES a single system covers most top-level jobs. Each agency is periodically given an allocation of spaces for establishing positions rather than getting individual position-by-position approval, as was true previously. Allocations are based on such factors as agency mission, program needs, and budget.

As of December 31, 1980, there were 7,042 SES members: 6.6 percent females, 7.3 percent members of minority groups, 91.0 percent career, 8.0 percent noncareer (10 percent limit), and 1.0 percent limited (5 percent limit) in the major occupational fields of Administration (32.2 percent), Engineering (14.2 percent), Physical Sciences (12.9 percent), Other Sciences (11.2 percent), and Legal (10.8 percent). Three-fourths of these individuals are located in the Washington, D.C. area.

First, let me talk about career employees. To enter the SES as a careerist you are subject to three requirements. First, you have to be selected through merit competition. Both your professional and executive qualifications will be evaluated by the agency's Executive Resources Board during the selection process. Second, your executive qualifications have to be certified by a Qualifications Review Board in the Office of Personnel Management.

All new SES members must show competency in six activity areas which are typically present in executive work. These are: (1) Integration of Internal and External Program/Policy Issues; (2) Organization Representation and Liaison; (3) Direction and Guidance of Programs, Projects, or Policy Development; (4) Resource Acquisition and Administration; (5) Utilization of Human Resources; and (6) Analysis and Review of Implementation and Results Achievement. You may qualify in these areas through successful work experience and/or completion of executive development programs for SES candidates. In exceptional cases, candidates may enter SES based on outstanding executive potential rather than actual experience or development.

Third, you have to serve a one year probationary period following appointment.

Your entrance pay is established by your appointing agency. Agencies set pay based on such factors as position responsibilities and a candidate's relevant experience, qualifications, and established earning level. Subsequent pay advancement and bonuses are determined by your agency.

Once you are in SES your agency has the authority to reassign you without Office of Personnel Management approval or further competition. There are no grades in the SES, and reassignments of SES members to positions which in the past would have required promotion actions (for example, from GS-16 to GS-17) are part of the flexibility provided by the new system. Being an SES member gives you increased opportunity for career mobility. You can be selected without further competition for any SES position, government-wide, for which you qualify.

There are only two types of positions in the SES—General, which are the norm, and Career Reserved, which include positions so sensitive that public confidence would be undermined if the functions were not performed by a career employee. Career employees, who are less than 85 percent of SES executives government-wide, may serve in either General or Career Reserved positions. Your rights serving in a General position are exactly the same as if you were serving in a Career Reserved position. Moreover, a career SES member can accept Presidential appointment outside SES with the right to return to the SES.

If you occupy an SES position, you are subject to a formal performance evaluation system. Goals will be set, and your performance will be evaluated against these goals. Your performance is appraised in terms of measurable, observable results rather than on personal characteristics. The goal-setting process includes determining both organizational and individual objectives, and is a collaborative effort between you and your supervisors. The assessment of your progress in meeting your defined goals is made by your supervisor and reviewed by a Performance Review Board in your agency. When a career executive is evaluated, a majority of the members of the Board must also have career status. Performance Review Board members may be drawn from within or outside the agency. The appraisal process helps you to succeed in new assignments by establishing clear expectations and goals. In addition, the process aids in planning for developmental opportunities to increase your effectiveness. You will be asked to identify and undertake activities that help you do your work.

Executive development programs are a source of support and aid in keeping up with new demands and changing conditions. These programs may include seminars, special assignments, professional society activities such as the team building and attendance at the Federal Executive Institute.

If you are an SES member with career status and your performance is inadequate, you may be removed from the SES and placed at GS-15, but you will retain your current SES salary. If you meet the age and length of service requirements, you will be eligible to elect discontinued service retirement instead of fallback. There is no appeal from these decisions.

By law, there must be at least five salary rates in the SES. Currently, there are six rates in effect. These are set by the President at the same time as annual comparability increases are authorized for the General Schedule. Presently, all these rates are frozen at $50,112.50 per year. By your own efforts you can have some impact on the compensation you receive. Many are able to earn substantial compensation increases. If your performance is excellent, it may be rewarded with a bonus or special rank. As a career SES executive you may be eligible for a bonus of up to 20 percent of base salary. Presently, no more than 20 percent of the total career SES in an agency can be awarded bonuses each year due to a Congressional limitation.

Also, as a career SES executive you are eligible for the rank of Meritorious Executive, which carries a lump-sum payment of $10,000 or the rank of Distinguished Executive, which carries a lump-sum payment of $20,000. An executive can receive either rank only once in five years, but an outstanding executive might receive both a Meritorious and a Distinguished award in that time frame. One percent of the SES are eligible for Distinguished rank annually and five percent for Meritorious. Bonuses and special ranks for career SES employees are permitted above the present Executive Level IV ($50,112.50) ceiling on base pay; and, in fact a high performing senior executive may receive in any one fiscal year total dollar compensation equivalent to the salary payable to a Cabinet member at Executive Level I (about $70,000). Bonuses and rank awards do not count toward the "high-three" for retirement. Only base pay is counted for the "high-three."

If you are an SES career member, after two years you may be considered for a sabbatical of 11 months if you have a total of seven years at the executive level and if you are not eligible for optional retirement. A sabbatical can be granted to an individual only once in any 10-year period. An additional benefit for all SES members is that you can accumulate unused annual leave without limit. This has a cash value when you leave the Federal Government. Once you have completed your probationary period, if you should leave the SES on a voluntary basis, that is, you are not removed for performance, disciplinary action, or security, you will have reinstatement rights to the SES. This probationary requirement was satisfied automatically by SES Charter members.

Some members have expressed concern about a possible intrusion of politics into the SES. There are many features of the SES intended to prevent this. But if these safeguards fail, the Federal Merit Systems Protection Board and Special Counsel have been established to guard against violations of merit principles. As a career member of SES, you are entitled to the same protections that all employees have against retaliatory or politically motivated actions. The independent Merit Systems Protection Board can order reversals of such actions and sanctions against individuals who took such actions. If you allege a personnel action was taken for political reasons or in retaliation for "whistle-blowing," you may bring the matter to the Special Counsel.

Let us turn now for a few final minutes to those who hold non-career and limited appointments. Briefly put: You serve at the pleasure of your agency head. You are not eligible for bonuses, meritorious ranks, distinguished ranks or sabbaticals. You may not serve in a Career Reserved position. You do not have tenure rights. But you will be paid at an SES rate determined by your agency head. You can receive an incentive award for excellence. You may accumulate unused annual leave without limit.

In summary, the SES is designed to create a cadre of individuals, recognized as competent and dedicated, who are accountable for the execution of Federal Government programs. Its members are eligible for special recognition and substantial cash awards for excellence. The Senior Executive Service is the keystone for achievement in the Federal Executive Personnel System.

Increasing Educational Programs in Fish and Wildlife

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Introduction

America has an increasing need for educational programs on fish, wildlife, and related natural resources for private landowners, urban dwellers, professionals, youth, and others. To avoid confusion and to focus further on a methodology of getting this educational information to many of these people, I will concentrate on a unique and extremely effective educational delivery system. This system, the Cooperative Extension Services, is not new. It was created by the Smith-Lever Act of 1914, and it is a three-way partnership involving federal, state, and county (or local) people and funds.

Through its ties to the land-grant system of colleges and universities of 1862 and 1890, Cooperative Extension provides informal, noncredit education primarily outside the classroom for adults and youth. As a "grassroots" directed program, it features the presentation of educational programs based on research findings, from the complete resources of land-grant institutions. It provides factual, objective, practical, problem-centered, and people-oriented information to enable people to help themselves—solve problems, make decisions, and take advantage of new opportunities. The people of each county, rural and urban, in every state and territory in the nation are the point of delivery, and this system and its capabilities are well known, especially by rural people.

Background

To provide some background regarding the education needs, I reviewed many references. One was an address on educational efforts made to the North American Wildlife Conference by Dr. C.B. Smith, Assistant Director of Extension, in 1936. The theme, "Wildlife Restoration and Conservation," and the presentations made at that conference enhance our appreciation for the great perspective of our earlier colleagues and provide a yardstick by which to measure our progress. Here are excerpts from Dr. Smith's presentation:

> I shall attempt to bring to your attention in a 10-minute paper something of the place the Extension Service of the United States Department of Agriculture and the 48 State agricultural colleges of this Nation are now playing and may play in the future in this work. The limited work thus far undertaken in wildlife fields by Extension forces has been largely through its boys and girls 4-H Clubs and chiefly in the States of Minnesota, South Dakota, Iowa, North Dakota, Nebraska, Missouri, Wisconsin, Michigan, Illinois, West Virginia and Massachusetts, although some work has been done in about six or seven other States.

[1]Effective June 17, 1981, USDA announced a reorganization which abolished the Science and Education Administration (SEA). Therefore, throughout this paper the reference to SEA-Extension should now be appropriately referred to as Extension Service.

Dr. Smith then elaborated, citing case by case examples of some of the outstanding 4-H accomplishments in fisheries and wildlife conservation work. However, in reference to the topic we are discussing today, I will again quote from his paper.

> A word now as to the potential significance of the Agricultural Extension Service in promoting the restoration and conservation of wildlife. The Extension Service, which is entirely an educational organization, is made up of nearly 8,000 State and Federal employees, all technically trained in the fields of agriculture and home economics. . . .
>
> The organization needed to utilize most effectively part of these Extension agents in promoting the restoration and conservation of wildlife would seem to be two or three agents in the Federal Extension Service, cooperating with the Bureau of Biological Survey and the Forest Service and employed to give their whole time to promoting this work through the State and county Extension Services.
>
> There should also be one or more persons in every State Extension Service to help State Extension forces understand the significance of the work in every county, and to assist in its organization and development, and to work through the State and county Extension organization in the most effective way. . . .

In closing this paper, Dr. Smith reiterated some of the significant needs, capabilities, and potential opportunities for Extension and for its delivery system, including 4-H and youth programs. He finished with the following statement:

> We can say to this conference, the Extension Service is squarely behind this great conservation movement and will play its full part in stimulating interest and knowledge throughout the Nation in the how and why of wildlife restoration and conservation.

Following this presentation, the Chairman, Ira N. Gabrielson, then Chief of the U.S. Biological Survey, introduced Jerry Flicek, the 17-year old champion 4-H conservation winner from Minnesota. Chairman Gabrielson (1936) summarized the extensive conservation accomplishments of this 4-H member as an example of such efforts by thousands of 4-H'ers across the country. His final statement to the conference about this effort was: "I wonder just how many of us have actually done as much as this youngster personally has for conservation in the last year."

We can learn from these quotes and the perspective of those who preceded us in our field. With their foresight and wisdom, let us examine the opportunities we have to provide educational programs in fish and wildlife.

Present Fish and Wildlife Extension Programs

In 1980, there were 70 professional fish and wildlife specialists in 30 of the 50 states, plus one fish and wildlife program leader in Washington, D.C., as their federal counterpart. Obviously, as times change so do titles of agencies, and now instead of State Agricultural Extension Service, most are entitled "State Cooperative Extension Service" (CES). At the federal level, instead of Federal Extension Service, it is the Science and Education Administration-Extension (SEA-Extension) in the U.S. Department of Agriculture (USDA).

For those of us involved in this educational effort, we deeply appreciate the suggestions and foresight of Dr. Smith, Ira Gabrielson, and others. However, the growth of this effort, although meaningful and extremely effective over the years in many states, has been somewhat restrained and, since 1936, has been severly neglected at the federal level. One position with both wildlife and fisheries responsibilities was filled in only about 2 of the last 43 years. I. T. Bode served for a year in 1936-37. The position was vacant until 1969, when it was filled by J.D. Almand, who left in 1970. Although needed more than ever before because of the increasing fish and wildlife programs developing within State Cooperative Extension Services, the position was again not filled until late in 1979.

In the interim period, because of the foresight and expressed need for educational Extension programs in fish and wildlife, many states CES' were employing fisheries and wildlife specialists. These specialists and their programs were well received, and they strengthened and broadened the total Extension program, which also was changing and broadening its clientele and educational programs.

Through the years, many people documented the need and supported and encouraged Extension to increase its efforts in fish and wildlife education. I would be remiss if I did not refer to some of these. You may wish to review some of the following references for further documentation: (Bode 1937; Berryman 1960, 1966, 1977; Smith and Berryman 1962; Cornwell 1967; Almand 1969; Benson 1977; Swanson 1977).

In discussing the status of current fish and wildlife educational programs in Extension, we need to have some idea of what kind of programs exist. The following list shows the variety of educational programs conducted by Extension wildlife and fisheries specialists.

1. General habitat management for wildlife and fish.
2. Awareness, appreciation, and encouragement for the ecological, economic, social, aesthetic, and environmental values that our renewable natural resources provide for the individual, the family, the community, and the nation.
3. Improving landowner-sportsmen relationships.
4. Forest-wildlife, farm-wildlife, range-wildlife, and urban-wildlife planning to examine and delineate the alternatives to the landowner/manager/user for managing and using these lands with wildlife as one of the objectives.
5. Freshwater fisheries pond management for recreation, food, expanded income, and multiple use.
6. Aquaculture-commercial fishery management.
7. Marine resources education and cooperative efforts with Sea Grant/Marine Advisory Programs.
8. Communication, cooperation, liaison, and complementary working relationships with other natural resources agencies, both state and federal.
9. Vertebrate animal damage control, including involvement in the integrated pest management program.
10. Management information for wildlife production, shooting preserves, fee hunting, fur farming, and other recreational uses.
11. 4-H and other youth educational programs.
12. Educational efforts related to threatened and endangered species, as well as critical habitat management and other environmental issues.
13. Identification of research needed, and interpretation of research accomplished, to implement educational programs in natural resources.
14. Participation on advisory and research committees and action groups with a variety of natural-resources-related agency technical assistance, financial assistance, research, educational, and policymaking groups.

15. Continuing education, inter- and intra-agency programs of in-service training for Extension personnel, other professionals in natural resources disciplines, conservation workshops for professional educators, and others.
16. Provide expertise to and liaison with sports groups, citizen groups, conservation groups, and state and federal agencies, with participation in professional societies and associations.
17. Recommendations to, and teaching of, environmentally safe and judicious use of pesticides, and provide factual information about the effects of pollution on the environment.
18. Coordinate and work closely with other related natural resources Extension programs to provide a comprehensive natural resources educational program.
19. Provide leadership for coordinating fisheries and wildlife education programs with other subject-matter disciplines to strengthen and broaden Extension's total program.
20. Other areas include public policy, assessment of resources, land use, and social changes influenced by federal and state legislation.

The educational programs and activities listed are neither all inclusive nor listed in order of priority. Also, no individual State Extension Specialist could possibly be expected to provide comprehensive educational programs in all of these areas. However, staffing and support capabilities *do* provide most of these educational efforts in a few states. Of necessity, each State Cooperative Extension Service must be flexible in designing and conducting its particular programs so they are tailored to the needs of its clients, coordinated with other agencies, and adapted to the professional capabilities of its personnel.

Programs conducted by fish and wildlife specialists in each state are based on expressed needs identified by "grassroots" clients. These programs join the Extension system's other educational efforts in five broad areas: (1) Agriculture, (2) Natural Resources, (3) Home Economics, (4) Community Development, and (5) 4-H Youth. The basic mission of all Extension programs is to provide educational programs to enable people to help themselves.

Extension is supported by the complete resources of the land-grant system which connects colleges and universities with about 3,150 county or local Extension offices in all 50 states, Puerto Rico, Guam, the Virgin Islands, and the District of Columbia. Extension includes more than 5,000 state and area subject-matter specialists and almost 17,000 professional educators, all with at least a bachelors degree and most with a masters or doctoral degree in sciences ranging from agronomy to wildlife; these agents have a respected history of performance.

The educational programs provided to an expanding clientele have developed a spirit of confidence in the capability and credibility of Extension. Through this system then, the entire services of the organization, as well as some services of cooperating agencies, are made available to assist private landowners, managers, and other citizens and community groups in weighing alternatives, making decisions, and implementing practices for developing, managing, and properly using resources.

SEA-Extension's Natural Resources Programs

As previously indicated, the need for Extension natural resources programs, specifically in fish and wildlife, has long been recognized. However, it is also obvious from the historical perspective that these programs at the federal level have been given a rather low priority. The commodity resources—food and fiber—are important to the welfare of the nation, but it is also important that educational programs devoted to the total resource needs of the people be recognized and given strong emphasis.

The Renewable Resources Extension Act of 1978 (Public Law 95-306) authorized $15 million annually for 10 years for expanded educational programs in five resources areas. They are: (1) forest land management, (2) rangeland management, (3) fish and wildlife management, (4) outdoor recreation, and (5) environmental management and public policy. Approximately 96 percent of the authorized funding for the Renewable Resources Extension Act (RREA) was to provide increased funding for strengthening and developing renewable resources Extension programs in the states. However, to date, not one dollar has been appropriated. In March 1979, the Natural Resources Unit of SEA-Extension was established and is headed by Merrill L. Petoskey, Deputy Administrator. The position of Program Leader for Fish and Wildlife was filled in October 1979. The roles and responsibilities of the fish and wildlife program leader are numerous, however, the position is basically the federal counterpart of state positions. It encompasses the responsibility of providing leadership for fish and wildlife programs. This includes the provision of encouragement, support, liaison, representation, planning, communication, coordination, development of training, advisory functions, and evaluation.

Increasing Opportunities

The Natural Resources Unit of SEA-Extension provides support for increasing opportunities in fish and wildlife educational programs. No funding for RREA has been appropriated, but the Unit and our program leaders are providing significant assistance to state CES programs. When the RREA is funded at the authorized level, it is anticipated that most states will establish fisheries and wildlife programs and other natural resources programs as determined by local needs. It is also expected that states with existing programs will strengthen and expand their present capabilities to address identified needs.

An even more immediate potential opportunity for increasing educational programs in fish and wildlife is through the memorandums of understanding between Extension and other federal and state natural resources agencies. Extension and other agencies have long-standing agreements regarding fish and wildlife programs. In 1936 the Federal Extension Service and the Bureau of Biological Survey signed a memorandum of understanding. Later, the Bureau of Biological Survey became part of the U.S. Fish and Wildlife Service (FWS) in the U.S. Department of the Interior, and a memorandum of understanding was updated in 1941. In 1946, a cooperative agreement was signed. In 1977, the most recent cooperative agreements and memorandums of understanding were made between SEA-Extension and the FWS and others between regional offices of the FWS and individual State Extension organizations. At present, Extension offices in 45 states, Guam, Puerto Rico, the Virgin Islands, and the District of Columbia have signed cooperative agreements with the FWS for coordinated and expanded educational efforts in fish and wildlife.

Other cooperative agreements and memorandums of understanding which strengthen educational programs in fish and wildlife include those with the Sea Grant/Marine Advisory Service—and those between some state CES offices and state fish and wildlife agencies. In some states, tripartite agreements have been made between Extension, the state fish and wildlife agency, and FWS. There are also cooperative agreements in some states between other state and federal agencies and Extension.

The cooperation between SEA-Extension, state CES offices, and the FWS has been strengthened considerably in recent years in a number of areas. However, this effort is expanding through establishment of the Office of Extension Education in the FWS and increasing opportunities for cooperatively funded projects and programs. There is an increasing awareness of the mutual benefit and stronger program capabilities with this direct coordination with the Extension Natural Resources Unit at the federal level and cooperation between regional and area offices of FWS and Extension administrators and their state fish and wildlife specialists. I admit we have a long way to go and I'm not sure that some of the FWS regional and area offices or state CES offices have noticed the potential this cooperative effort affords. However, thanks to the foresight of Jack Berryman and others, the framework is in place and working. Since late in 1978, more than $400,000 has been used in cooperative efforts for Extension fish and wildlife educational programs between the two agencies. If in-kind funding amounts were included, this figure would exceed one-half million dollars.

Another positive and important element of support has been achieved with recognition by the Extension Committee on Organization and Policy (ECOP) of the need for expanded fish and wildlife and other natural resources programs. This is evident by ECOP support for RREA at the policy and budget levels to SEA-Extension.

Obviously, these indicate areas of increasing opportunities. Many others exist, some of which are already working, such as the enhanced communication and cooperation between Extension and state fish and wildlife agencies. Through cooperation with the International Association of Fish and Wildlife Agencies, one or more Extension contact persons have been named with 32 state fish and wildlife agencies, the Tennessee Valley Authority, one Canadian province, and Mexico.

A cooperative regional workshop has been conducted with Extension fish and wildlife specialists, the Cooperative Wildlife and Fisheries Research Units personnel, other FWS personnel, and respective state fish and wildlife agency personnel. We have been working cooperatively with other agencies, including the Soil Conservation Service in their Resources Conservation Assessment and the National Biologists Workshop, and there is effort underway to set up cooperative meetings in aquaculture. Recently, the Southeastern Extension fisheries specialists met with the Regional Fisheries Research Group, S-83, to participate in an advisory working group to assist in identifying research needs and to increase opportunities for interpreting accomplished research. At present, we are pursuing the possibility of cooperatively funded efforts for educational programs in fish and wildlife between SEA-Extension and the State and Private Forestry component of USDA's Forest Service. There have also been a number of regional "association" meetings where Extension fisheries and wildlife specialists, FWS personnel, and other state and federal agency personnel met to discuss needed educational efforts and programs.

Today, the movement for increased fish and wildlife educational opportunities has accelerated with the recent establishment of the USDA "Policy on Fish and

Wildlife," Secretary's Memorandum No. 2019, the passage of the National Aquaculture Act of 1980, the impending funding of the Renewable Resources Extension Act of 1978, and the many opportunities for cooperative programs between Extension and other agencies. However, this movement may be slowed without the authorized, but yet-to-be-appropriated, funding to put into place the money "earmarked" for renewable resources Extension programs.

I hope this description of where we are now, the opportunities for increased efforts and the review of past perspectives which identified the need for increased Extension efforts in fish and wildlife educational programs will stimulate your appreciation and support for expanding these efforts. Despite Dr. Smith's statement of need 45 years ago, we still do not have an Extension wildlife and fisheries program in every state. However, in those states with existing programs, my counterparts make up a cadre of outstanding professionals, with very progressive programs. If your state does not have such programs and you feel they are needed, contact your Extension Director and discuss this need.

In another comparison, if we look at 4-H (one segment of our work), we see over 205,000 youngsters participating in fisheries and wildlife projects each year. However, this project area is the only one in 4-H with an enrollment of this magnitude which does not have a national donor. In fact, even though a formal proposal was written in January 1980 and has been presented to several potential donors, it still lacks sponsorship. Fortunately, we were able, with the support of the Fish and Wildlife Service, to provide the national recognition for outstanding 4-H fish and wildlife members and volunteer leaders for the first time ever at the opening session of this conference. The reason for the discussion about 4-H fish and wildlife efforts is that this educational endeavor motivates 4-H youth to have an appreciation and concern for natural resources management throughout their life. Obviously, the need expressed by Dr. Smith in 1936 "for two or three Federal Extension agents and an Extension agent in each State charged with the sole responsibility of developing this work" still has not been achieved. However, our progress is significant. Today, we have 70 Extension wildlife and/or fisheries specialists in 30 states and one fish and wildlife program leader in SEA-Extension. Other program leader positions in SEA-Extension's Natural Resources Unit provide comprehensive natural resources leadership and support for programs in forestry, range, recreation, and environmental quality.

The Office of Extension Education established in the FWS has contributed significantly in the funding of cooperative extension educational projects and in the dissemination of materials available from the various units of FWS. At the federal level, we communicate regularly and try to meet for a couple of hours at least once a month to evaluate cooperative project proposals, coordinate with other FWS offices, and discuss and work out any hitches in our coordination. We also have periodic meetings with other cooperators, including the Sea Grant/Marine Advisory Program, the International Association of Fish and Wildlife Agencies, Forest Service, Soil Conservation Service, and other federal and state agencies.

Summary

Obviously, with increased "earmarked" funding for natural resources, Extension's educational programs, including fish and wildlife, would significantly increase. However, I must congratulate the numerous supporters both within and outside Extension for the status of the fish and wildlife Extension efforts we have today. Directors and administrators of the Cooperative Extension Services reacted to the needs expressed by the expanding clientele they serve, and they staffed the positions we find in the states today.

The specialists responded enthusiastically. They helped identify the need, developed programs to fill those needs, developed high credibility in the professional community, and conducted excellent programs with little support, until recently, from the federal level.

County Extension agents, the Extension source of knowledge at the local "grassroots" level, acknowledged their need for fisheries and wildlife educational programs. In those states with existing programs, a truly symbiotic relationship exists. The beauty of this relationship is that the total Extension program benefits. However, the ultimate benefactors are the people—Extension clientele and the renewable natural resources they manage. Other cooperating fish and wildlife or related natural resources agencies also benefit through the complementary relationship to their programs. Admittedly, Extension's expanding clientele are not exclusive; we share with others who provide educational, financial, and technical assistance programs. However, many people reached through the Extension delivery system probably would not be reached through other federal or state agencies with regulatory authority or advocacy programs.

We have a job to do both within and outside our own organization to garner increased and needed support for fish and wildlife educational programs. With foresight on our part, it is easy to envision the increased need for factual, objective, research information on fish and wildlife management and use, interpreted in a common-sense fashion and delivered to the people.

Our clients are becoming progressively more knowledgeable in some areas, more diverse, more urban, and further removed from the land. Too many lack an appreciation and respect for how renewable natural resources must be managed to provide our needs and enjoyment. We must be dynamic and meet this challenge, take advantage of the opportunities and work together to assure that factual, biological resources management for the future is supported by an educated citizenry. I challenge you to support this effort to assure that fish and wildlife Extension education becomes a reality in every state in this nation.

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The Resource Manager and the Public: An Evaluation of Historical and Current Concepts and Practices

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Introduction

Hunting has changed throughout history. The needs of primitive people, the hunter and food gatherer, were undoubtedly utilitarian. They were motivated to secure other animals for food and fiber. Hunting with the expectation of securing food and fiber was also an important and necessary aspect of the frontier society in North America when game was plentiful and hunters few. Utilitarian hunting (Kellert 1980) evolved in various cultures and still exists within a few societies. Today, however, hunting motivations are largely related to human recreation. Hunting traditions, and subsequent rituals, have undergone an evolution. Professional wildlife managers have historically responded to this evolution by managing wild game populations in a fashion that will provide the greatest number of harvestable animals and by creating hunting situations that maximize harvest opportunities. A continuously dwindling habitat base, coupled with an increasing hunter population, concentrates hunters and induces a modification of previous hunting methods so that the hunter may bag an animal. Increased hunter demands, born out of *learned expectations,* compel wildlife agencies to manage wild and artificial populations and hunting situations even more intensively (Brown et al. 1977). In the process, some important components of the recreational hunting experience may erode away and become lost.

In assessing the significance of these lost or distorted components we suggest that certain management and hunting practices be evaluated by a Leopold (1933) theorum, "The recreational value of a head of game is inverse to the artificiality of its origin, and hence in a broad way to the intensiveness of the system of game management which produced it." To illustrate, concentrations of deer hunters develop in some areas in densities of more than 100 per square mile (2.6 km^2) with the hunter outnumbering the deer by ratios as high as 4 to 1. The hunter cannot practice total recreational hunting under these circumstances, but he does adapt to the new situation by merely standing in a likely area and watching for an animal that has been moved by other unknown hunters and then shooting it, or at it when it passes. This becomes an accepted method of hunting and hunters purposely seek out areas where there are enough other hunters "to move the deer." Participation in a *total* recreational hunt gives way to the development of new, more artificial practices. Derived from the same Leopold theorum, we propose a definition of a total recreational hunt as the opportunity to practice hunting skills under conditions in which the animal is permitted its normal behavior pattern (appropriate to the season) in its natural habitat; consequently, hunting skills must include an intimate knowledge of the quarry's daily and seasonal activities and of the area being hunted. Some historical and current management practices are counterproductive to this definition and may, in fact, distort both hunting behaviors and the professional values held by most managers.

For example, wetland management plans are designed to facilitate the harvest through a patterned series of drawdown, food growing, and reflooding in time for the arrival of migrating ducks. Waterfowl shooters are attracted to, and become concentrated in, such baited areas. The Canada goose (*Branta canadensis*) population in the Mississippi Flyway is managed at levels far above historic populations, to meet the expectations of today's goose shooter. Disease threatens these unnaturally concentrated populations and considerable research management effort has gone into finding methods of dispersing the population over a wider area to provide shooting for more hunters and to minimize the disease potential. Shooters harvest geese from permanently positioned blinds on public lands after receiving cursory instructions from agency *shooting managers* at the site. Geese are baited to "landing strips" of freshly sprouted winter wheat or rye for shooting on public lands; the 4-inch (10 cm) new growth is timed to coincide with the peak of goose migration. Hunters concentrate along firing lines on the periphery of refuges, adorned with tennis shoes to facilitate the foot-races to downed birds. They consider it a successful hunt if they burn up several boxes of shells while shooting at high flying geese; and *highly* successful if they are fortunate or fast enough to be the first to get a downed goose. The art of actually hunting geese by observing feeding patterns, blind positioning and decoying is rare and becoming rarer. Doves (*Zenaidura macroura*) are baited into shooting position on public lands by cultivating acreages of sorghum in strategic locations. The shooting season is set to open after the doves have become conditioned to the undisturbed feeding situation. Shooters are permitted to literally surround the field and in so doing, jeopardize each other's safety with concentrated shooting. Personnel from local TV stations shield their camera lenses from the raining shot as they record the event to provide the general public a firsthand account of modern hunting. This dove management was considered to be so successful by one wildlife manager that he seriously considered applying the same practice to prairie chickens (*Tympanuchus cupido*). Success in these cases is measured in numbers of birds harvested per shooter.

Forest trails and roads are seeded to white clover to bait ruffed grouse (*Bonasa umbellus*) into a position where they are more accessible to shooters and woody vegetation is cut back along the edges of roads to provide better shooting. The grouse do not need the clover in the fall, a time of the year when a variety of natural foods are superabundant, but this practice has become synonymous with ruffed grouse management. The number of grouse harvested per mile of road driven has become the measure of success, and hunting with a motorized vehicle has become the accepted method: for many it is the *only* method.

New equipment and gadgetry make hunting more comfortable and the game more accessible with less physical effort. Pick-up trucks, airboats, snowmobiles, and all-terrain vehicles (ATV's) become standard equipment for hunting many species. Equipment that provides the hunter with undue advantage over the wild one is often accepted or ignored by wildlifers who judge the success of a season in terms of the total harvest and hunter success ratios. New hunters, who find these practices appealing, are initiated under this system and the practice grows geometrically; much more rapidly than one generation at a time as in the past. New ethics evolve concomitantly with the change in methods and equipment. As the demand for game increases, and the supply becomes scarcer, we search for management methods that will further increase the supply to meet the demand. We even adopt and easily justify artificial techniques to put something in the game bag to satisfy the hunter who has now become merely a shooter. We take the ultimate step and resurrect the practice of rearing animals in captivity to insure maximum production and then release them before the gun under quasi-natural conditions, e.g., the pheasant (*Phasianus colchicus*) stocking programs. Methods of shooting which develop around this maintenance stocking practice include following the stocking truck to the release site and shooting the birds as they are released from the crates on the back of the truck, although some agencies attempt to insulate their hunting clientele by secretly stocking the birds at an unobtrusive time. Motivations to shoot a "wild" animal are fulfilled, the methods become traditional, and the practice a ritual to be taught to new hunters and passed on to succeeding generations. These recreationists sincerely believe that they are hunting. They naively practice that which was considered to be unethical and unsportsmanlike only a short time ago simply because they know of no other way. Wildlife management for some is now equated with stocking animals before the gun. When this happens the wildlife management profession may be *unconsciously* promoting unethical hunting behavior by conscientiously meeting the short-term demands of the hunting public while short changing the responsibility of their offices as public servants.

Certainly resource managers now recognize that promotion of ethical sportsmanship is an essential element of their professional responsibilities. The understanding and utilization of psychological and educational theories have been found to be important not only in informing and communicating with the public, but also in assessing the impact of management practices on the behavior of resource users. A survey of the literature and practices of game management confirms that the objectives and success of such management have been measured in part by the satisfactions reported by resource users. "In the early days of game management in the United States, the amount harvested was a logical measure of success, so the 'game bagged' objective directed managers' efforts" (Potter et al. 1973). The authors also suggested that when smaller game populations led to a lesser probability of success that a new "days afield" objective emerged to guide game managers. The concept of a "multiple satisfaction" alternative was developed to identify a broader range of hunter satisfactions and experiences for a variety of hunters (Potter et al. 1973). Common to all of these criteria is the concept that hunter satisfaction is the direct goal of game management, but often forgotten was the relationship of satisfaction and motivation to responsibility and other important ethical variables.

Research Objectives and Methods

The Wisconsin Hunter Performance Study is a comprehensive and complex project designed to develop a psychology of the different kinds of hunting (waterfowl, deer-gun, etc.) and also to apply findings and concepts to the problems found in both *managing* and *educating* hunters and other outdoor recreationists. The specific objectives of the studies were to determine: (1) the nature of the formative antecedents, hunting behaviors, and satisfactions of different kinds of Wisconsin hunters; (2) the differences between behavior, expectations, and satisfactions as expressed through self-report and as observed in the field; (3) the variations in hunter behavior and satisfactions among hunters having different demographic and psychological characteristics, hunting at different times and under different physical conditions and regulations.

The initial phase of these studies focused on waterfowl hunting because it permitted the direct observation of hunter behavior and because of the many legal issues and actions associated with the hunting of this particular kind of wildlife. The entire first year of the study was used to develop and field test the instruments and questionnaires for the research activities. In particular, the researchers were concerned with refining a technique for the direct observation of hunting behaviors. The instrument used to record the observed data was partially based on the Hunter Performance Survey (HPS) developed by the U.S. Department of the Interior for its studies of waterfowl hunters' behavior in relationship to bag limit regulations. After expanding the HPS form, the researchers trained student assistants to observe and describe in detail hunting conditions, hunter behavior (including violations), as well as the number of waterfowl shot, retrieved and lost. Hunters were watched from points of concealment (spy blinds) with the assumption that they would be unaware that their activities were being watched and recorded.

Observational data were collected over two hunting seasons using retired game wardens and students from the University of Wisconsin-Stevens Point and the University of Wisconsin-La Crosse as research aides. To be certified to observe, each student had to successfully complete a 16-hour course devoted to (1) waterfowl identification, (2) the study of state and federal regulations, and (3) observation skills and competencies.

The second technique used in data collections was a field interview conducted by the observer at the completion of the hunt. The researchers introduced themselves to the hunter and then conducted a short field interview designed to elicit (1) demographic data, (2) an expression of satisfaction and dissatisfaction with the hunt, and (3) validation of the observers conclusions about the day's hunt. During the two hunting seasons through which this research was conducted, complete field data were collected on 596 hunts representing 583 hunters. These hunts all took place in five representative waterfowl hunting areas selected by Wisconsin Department of Natural Resources (WDNR) game management personnel. The locales ranged from the highly regulated and hunted state or federal public hunting areas in eastern Wisconsin to relatively secluded parts of the Upper Mississippi Wildlife Refuge and the Central Wisconsin Wildlife Areas.

In designing the deer-gun phase, pilot studies indicated that spy-blinding was cold, dangerous, and impractical. While some observations were made by landowners and hunter safety instructors, the major source of data was from hunters contacted through interviewers who followed prescribed road routes and stations in ten Wisconsin deer management units. The units were chosen because they represented most of the variables used in classifying and categorizing Wisconsin deer hunters: type of terrain, hunting pressure, size of deer herd, and distance from population centers. Over the two seasons during which the study was conducted, 1,223 hunters (ranging from 65 to 261 hunters per unit) were interviewed.

A composite of all these hunters is typical of the major demographic characteristics of Wisconsin deer-gun hunters described by the earlier Klessig-Hale study (1972) of Wisconsin hunters (age, sex, resident or non-resident, size of community, etc.). Students from six state university campuses were trained to conduct the field interviews, all working in management units nearest their campus. Resource managers and wardens had indicated on county and township maps those areas within the units where hunters were most likely to be contacted. Managers made estimates of the percentage of hunter success and hunting pressure for each unit and for each day of the season. Stratified samples were collected based on those estimates.

The third technique used in data collection for both the waterfowl and deer hunting phases of the study was a post-season interview conducted in the homes of the hunters previously contacted in the field. The interview used a 12-page questionnaire which included demographic items, self-rating scales, and open-ended questions. While the majority of the questions were the same for both waterfowl and deer-gun hunters, some were explicitly directed at the special hunting conditions and methods of each form of hunting (i.e., the point system and use of retrievers for waterfowl hunting; use of tree stands, and the organization of group drives for deer-gun hunters). The research investigators trained over 50 psychologists, teachers and counselors to conduct the home interviews. All of these men and women were or had been hunters, had degrees, and had prior training in one-to-one communication. Any bias these interviewers might have had by training or occupational experiences was consistent with that of the project's directors. All interviewers were required to participate in a four-hour training program to familiarize them with the nature and objectives of the research project and to standardize their approach to the hunters and the questioning techniques used in the interview. To be certified to interview, the trainee had to demonstrate competence, as judged by one of the investigators, while interviewing another trainee and completing the post-season questionnaire. This role-playing enabled the researchers to judge the competency of each candidate under appropriate controlled conditions. Home interviews were conducted with 442 of the observed waterfowl hunters (75+ percent) and with 258 deer-gun hunters selected at random from those hunters interviewed in the field (approximately 25 interviews were obtained from those hunting in each of the 10 deer management units).

Results

As Langenau (1979) suggests, research on hunter satisfaction is probably "the most advanced in the wildlife human dimensions field." It is also probably the most complex because of the difficulty in separating what hunters do from what they say, and the vast individual differences created by both internal and external factors. Some conceptual schema are needed for the analysis of hunter satisfaction that integrate facts, data, and past research results into a meaningful network of related ideas. This report of research results is organized in five schema related to the patterns of individual differences found in the hunter populations studied in this research.

Schema # 1. Recognize that there are individual differences in the expectations, satisfactions, and motives of hunters.

Some of the differences to be found in the research literature on hunter satisfaction undoubtedly relate to important and even subtle differences in the methods and the questions investigators have used in pursuing this topic. In this study, satisfaction was measured at various times (pre-season, day of the hunt, and post-season interviews), with different questions, and for different kinds of hunting.

When hunters were asked after the season, *"Why do you hunt?"*, over 80 percent of the waterfowl and deer hunters gave answers which fell into one of three categories: (1) *development and testing of hunting and recreational skills* (26.6 and 36.6 percent respectively for waterfowl and deer hunters); (2) nature appreciation and getting out-of-doors (36.1 and 31.5 percent); and (3) escape and solitude (18.9 and 16.9 percent). While the differences in distribution between waterfowl and deer hunters were significant, none of these three categories indicate killing as a primary motive. Killing food, bagging game, and competition with other hunters were seldom mentioned! In contrast, when asked, after the season, what was the "most satisfying aspect" of the past season, the largest percentage of both waterfowl (48.0) and deer hunters (31.2) cited bagging game. Yet in that same home interview, when asked to rate identical lists of 16 variables in terms of their "importance to your satisfactions as a deer (or waterfowl) hunter," killing game ranked 14th and 13th respectively.

Much of the research literature is based on the measurement of satisfaction as expressed by hunters on the day of the hunt. In these Wisconsin studies all hunters were asked in the field at the end of the hunting day, "How was your hunt?" Responses were categorized as positive (satisfied) when the hunter checked excellent or good, and were coded negative (dissatisfied) when the response was fair or poor. Because hunter success has been found to be strongly associated with the evaluation of satisfaction on the day of the hunt, separate statistical tests were conducted for that group which had bagged game and for those hunters who had not been successful. As can be seen in Table 1, five factors were found in common to be significant attributes of both successful and unsuccessful *satisfied* waterfowl hunters. Satisfied hunters were more likely to travel greater distances to hunt, hunted in larger parties, fired more shots, behaved more unethically, and were more likely to be hunting geese as well as ducks (for ease of reading, the chi squares, f ratios, and degrees of freedom were omitted from the Table but are available from the researchers).

Satisfied successful hunters did *not* kill more ducks than those who said they had fair or poor days. They reported, however, that they found greater satisfaction from compansionship, from justification in killing an animal, and from positive experiences with other hunters. They were observed committing more game law violations. In contrast, satisfied unsuccessful hunters seemed less intense about their hunting, cited lower anticipation of waterfowl season and were more likely to prefer bow hunting and other forms of athletic sports and recreation. Their hunting profiles emphasized satisfaction from the natural scene, rather than killing the bag limit. They were bothered by environmental violations, enjoyed low hunting pressure and showed their satisfaction by spending more time in the field on the day of the hunt than those who gave a negative rating to their day.

Schema # 2. Recognize that there are individual differences in satisfaction based on changes over time (years of experience and age).

We have previously reported our theory that hunters develop through *stages* of hunting behavior (violations) based on both years of experience and age (Jackson et al. 1979, Jackson and Norton 1980.). To further explore this concept, the

Table 1. Selected attributes of both successful and unsuccessful waterfowl hunters expressing positive satisfaction towards their days hunting experience.

Factors	Significance level successful hunters	Significance level unsuccessful hunters
Factors found in common in both successful and unsuccessful hunters expressing positive satisfaction.		
1. Traveled a greater distance from home to hunt	.01	.01
2. Hunted in larger parties	.05	.05
3. Committed more ethical violations on day of hunt	.05	.05
4. Hunted for geese as well as ducks	.01	.01
5. Fired more shots on day of hunt	.01	.01
Factors found in *successful hunters only* expressing positive satisfaction.		
1. Committed more game violations on day of hunt	.05	
2. Rated self tendency to violate as being lower:		
a. For hunting waterfowl	.05	
b. For hunting small game	.05	
3. Rated companionship and competition with other hunters as the most important reason for hunting	.05	
4. Less likely to have shared blind with members of party	.05	
5. Less likely to have used duck call	.05	
6. Experienced positive relationships with others hunters in the field	.05	
7. Hunted fewer days during the waterfowl season	.05	
8. Able to identify more ducks correctly during field check	.01	
9. More optimistic about the development of waterfowl hunting in Wisconsin	.05	
10. Felt more justified in killing an animal	.05	
Factors found in *unsuccessful hunters only* expressing positive satisfaction.		
1. Satisfaction evaluations based on natural scene and utilization of hunting skills		.05
2. Gave higher rating to satisfaction derived from low hunting pressure		.05
3. Influenced in the development of hunting attitudes by environmental rather than personal models		.05
4. Bothered more by environmental violations of other hunters rather than hunter-hunter relations		.05
5. Less likely to have found satisfaction in killing the bag limit		.05

Table 1. Continued

Factors	Significance level successful hunters	Significance level unsuccessful hunters
6. Anticipated waterfowl seasons less than other forms of hunting such as small game, pheasant and bow		.05
7. From listing of major types gave highest preference rating to bow hunting		.01
8. More likely to have participated in other forms of athletic sports and recreation		.05
9. Spent more time in the field on the day of the hunt		.01

responses of the waterfowl hunters to 16 Likert scale satisfaction variables were tested against these two dimensions. In assessing the association of hunting satisfaction with *years of experience,* significant differences were found in the mean ratings for nine of the 16 items. As shown in Figure 1, hunters with one or two years of hunting experience gave the lowest mean rating to six items, and those with three to five years ranked these second. The rating of nature appreciation by these two groups of less experienced hunters was reversed, but still lower than that of more experienced hunters. All of these seven items could be conceptualized as internal rather than external in their orientation and not directly related to the taking of game. In contrast, hunters with three to five years of experience gave the highest mean rating to taking trophies, killing the bag limit, and doing better than friends. Hunters with 16 or more years of experience gave these three items the lowest ratings. Significant differences were also found for 9 of these 16 satisfaction factors when tested in terms of *age groupings.* Hunters in their teens gave the highest ratings to taking trophies, killing bag limit, doing better than friends and getting a lot of shooting. Comparably they gave the lowest mean ratings to escape, appreciation of nature, exercise, and outdoor activity, and companionship of a friend.

Schema # 3. Recognize that there are individual differences in hunter satisfaction varying with the season of the year.

One possible explanation for the different and apparently conflicting evaluation hunters give for their motivations and satisfactions is the variance in perception, orientation, and state of mind depending on whether they are looking at hunting before, during or after the season. In a related study, we asked over 400 deer-gun hunters attending pre-season hunting clinics to rate their *anticipations* concerning the coming season. Out of 18 listed factors, these hunters gave the highest ratings (on a 5-point scale) to the following: (1) anticipation of a clean kill (4.37); (2) preparing my equipment (4.13); (3) scouting the area to hunt (4.08); (4) returning to particular locales or favorite hunting areas (4.08) and (5) practicing shooting skill. Factors relating to seeing and killing deer followed next in the rank ordering. These results suggest an orientation of the hunter to those activities and *satisfac-*

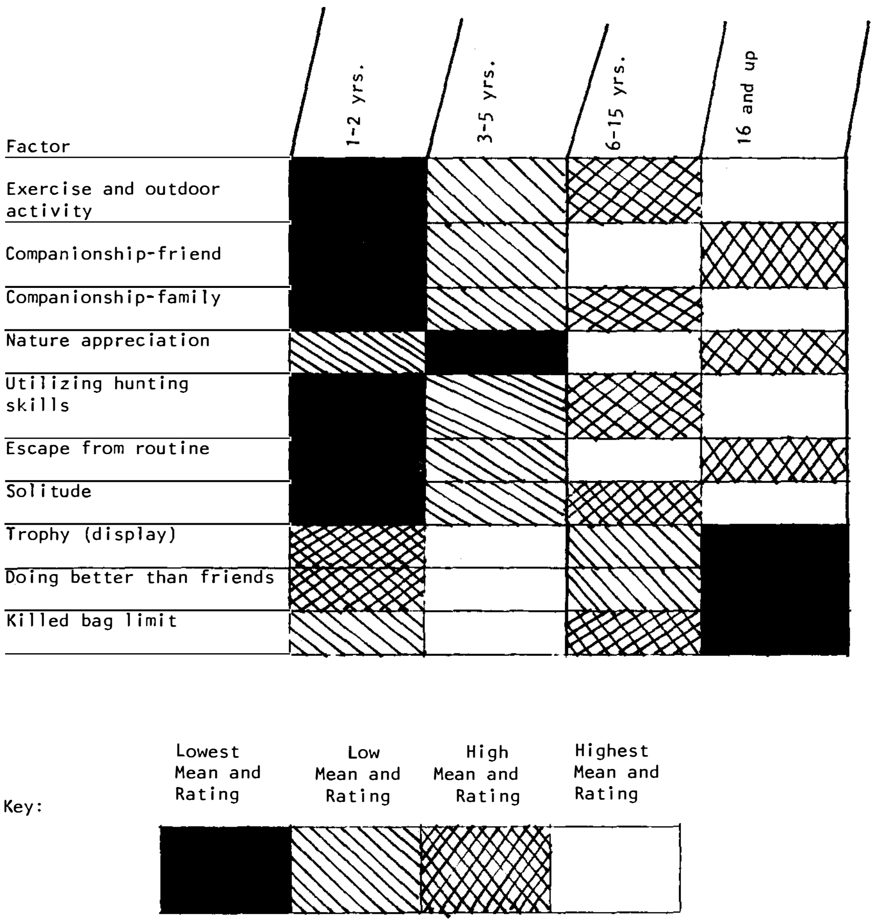

Figure 1. Summary of association of hunting satisfaction rating and years of hunting experience—waterfowl.

tions appropriate to the pre-season time period (preparing equipment, scouting, etc.), and a mounting interest in the bagging of game. The significantly higher rate of violation observed by the researchers on opening day and during the first week of the season than later provides support to the thesis that pressures and satisfactions related to killing game may peak early in the season. Thirty-eight percent of the Wisconsin deer-gun hunters surveyed by this research gave additional support to this schema by responding affirmatively to the question, "Do the attitudes and practices of your hunting party change over the nine days of the season?"

After the season, hunters seem to again change their orientations and perceptions of hunting. The final question in the post-season interview was, "If you knew you had only one more hunting day in your lifetime, how would you spend it?" As the concluding question in a two-hour interview, it was designed to probe their central motivations and satisfactions. The hunter who responded that he would "break every bag rule in the book" was very much the exception. The majority of hunters never mentioned bagging game. They described companionship with family or hunting partner, aesthetic qualities of nature, an experience shared with a dog, and *seeing* game and non-game species. Apparently time helps the hunter digest past experiences. Many hunters described in their interview responses a process of evaluation, reflection and consequent adjustment of satisfaction and expectations.

Schema # 4. Recognize that there are individual differences in the expectations and satisfactions of those hunting different species.

For this schema it is hypothesized that while some satisfactions are generic to all hunting, others are specific to each special type. The entire population of waterfowl hunters ($N=594$) and deer-gun hunters ($N=1{,}223$) responded to the same question in the field interview, "How was your hunt?" The question was stated in a way to avoid obvious reference to bag; (i.e., how did you do?). The intent was to make possible a wide range of responses depending on the individual expectations and orientations of the hunter. As can be seen in Table 2, significant differences in the percentage of response were found in the comparisons of the two types of hunters. Only 9 percent of the waterfowl hunters rated their hunt as excellent while 49 percent stated that it was poor. In contrast, the distribution across the four levels of satisfaction for deer hunters was significantly different with 18 percent indicating it was excellent and 34 percent calling it poor. Hunters were also asked to describe their most dissatisfying experiences. Seventy percent of the waterfowl hunters responding to this post-season question cited the unethical behaviors of other hunters toward the wildlife resource or other hunters. The next highest response category was "not seeing game" (7.5 percent). The largest percentage of deer hunter dissatisfaction was for weather (22.6 percent) while other hunters named not seeing game (18.1 percent) and the ethics of hunters toward other hunters (also 18.1 percent).

Schema #5. Recognize that there are individual differences in the motivations and satisfactions varying with local, regional and state populations.

Wildlife researchers studying human behavior, attitudes and values have been justifiably cautious in generalizing findings or concepts across state lines. Equal concerns should be raised about the individual differences that can exist within regions of the *same state*. For example, significant differences in field satisfaction ratings were found in the comparisons among five state waterfowl areas studied.

Table 2. Percentage of Wisconsin waterfowl and deer hunter responses to the question, "How was your hunt today?"

Response category	Percentage of waterfowl hunters $N=594$	Percentage of deer hunters $N=1223$
Excellent	9	18
Good	22	25
Fair	20	23
Poor	49	34
	(X^2 (3) = 44.70, p. 00.)	

The highest mean rating of hunter satisfaction was found in that area with the *lowest average daily bag* per hunter. This same population of satisfied hunters also had significantly lower scores on an information test about waterfowl identification, fired fewer observed shots per trip, had a lower percentage of hunters violating game laws, and a larger percentage of hunters showing good sportsmanship.

Numerous statistical tests were made between the Likert scale satisfaction ratings of deer-gun hunters and other potentially important associations (occupation, size of party, days hunted, etc.). Only rarely was the .05 level of significance reached. However in inferential comparisons of the mean satisfaction ratings with the 10 deer management units, significant differences were found for 8 of 16 items including: companionship of a friend; use of a high powered rifle; killing deer; escape; displaying a trophy; use of outdoor skills; getting shooting; and doing better than friends. Complete analysis of all data by management unit suggested unique hunter profiles which apparently were associated with hunting regulations (e.g. rifle hunting permitted), distance from population centers, topography, etc.

Discussion

Conceptual unity may seem incongruous to any exposition of results which stresses individual differences in hunter motivation, expectation, and satisfaction. There are, however, important common ideas which suggest a network of related ideas. In identifying these concepts, we have turned to hunters rather than management practices. Wildlife managers who have accepted size of bag as one of the major measures of hunter satisfaction tend to use this criteria to judge their own professional success. They seek to influence hunter satisfaction through utilizing management tools that affect deer density, hunter density, camp accessibility, hunter access, etc. (Kennedy 1973).

Our evaluation of psychological theory and research suggests that satisfaction is based on *expectation* rather than on end products and results. Researchers have long wondered why obvious winners were often less satisfied than those with poorer performance. These incongruities, as well as those in the hunter satisfaction literature, make sense if interpreted by this expectation concept. How else can we explain why 25 percent of the Michigan hunters who shot bucks did not see a high quality hunt in their evaluation (Langenau 1979) or Kennedy's finding (1974) that 62 percent of the Maryland hunters studied reported good or excellent hunting even though the success rate was 3 percent and almost half of the hunters did not see deer. Hunting satisfaction is not always directly equivalent to the kill rate or personal success factors. Maryland hunters, with low expectations of success, describe satisfaction in terms of companionship, solitude, food, and nature appreciation. With low expectations for a kill, other satisfactions become more important. In Wisconsin, comments in the news media push hunters to expect shooting success. The media report a million deer in the woods and that over 100,000 hunters will shoot a deer. This forecast easily becomes an expectation and an absolute goal for the individual hunter. It helps explain why one Wisconsin hunter who shot a nice buck at 10:00 a.m. on opening day told us that his hunt was only fair and described his most satisfying experience as the bottle of beer he had that afternoon. The post-season interviewer discovered that this hunter's expectation (goal) for the season included a larger trophy buck and a full nine days of hunting.

Most deer hunters would prefer to bag a buck on the last afternoon of the last day of the season. The hunter who took the buck on the first day was in a dilemma because hunting activity was almost equally as important as bagging a deer. The media have a great impact on user expectation, particularly those of the young and inexperienced, and the self-taught sportsperson. Departmental reports of local fishing and hunting successes and articles in popular magazines all build user expectations along with accounts of unrealistically successful expeditions to areas where fish and game abound. The sportspersons who flock to these areas with high expectations often find that fish are no longer biting or that the woodlands are posted in response to a sudden surge in hunting pressure. Newspapers publicize "big buck contests" and glorify "trophies" rather than the satisfactions derived from other broader experiences. Managers, too, create expectations simply by setting bag limits. Individual users have *learned* to equate hunting satisfaction with "limiting out." Hunters told us of pushing beyond their own physical limits to "fill up." In broadcasting their own management achievements in producing greater wildlife populations, fish and game departments have become their own worst enemies. Public information offices, hunter educators, and game management personnel should rather be seeking to change hunters' goals and expectations. These are the critical inner controls that actually determine user satisfaction and behavior.

Logically, hunter expectations in the Upper Midwest should have changed over the last few decades as fewer ducks and more deer were observed. Interviews with experienced hunters indicated that these expectations haven't always been adjusted with game populations. When half of the waterfowl hunters interviewed had a "poor" day, it may be in part because expectations learned from the "good old years" still have a distorting effect on today's anticipations. Comparably, an individual hunting deer in a county that didn't even have a huntable population four decades ago won't be dissatisfied when he sees 20 to 40 deer on opening day. In explaining the differences in waterfowl and deer satisfactions in the field, the manager should keep in mind that poor ethics of other hunters dominated the dissatisfactions cited by the interviewees. Also, waterfowling, more than perhaps any other kind of hunting, is "an experience where everything has to go right and it always seems to go wrong" (motor, trailer, decoys, etc.). Deer hunting, in contrast, is often a group activity in the Midwest and thus offers a different basis for satisfaction. Traditional hunting parties with family ties are not uncommon. Hunters told us that the only way to get into these established groups was through name or marriage. Those who did belong to such groups emphasized the group experience and its contributions to the satisfactions that make deer hunting, for many, the most important hunting or non-hunting event of the year. Why does any group relationship grow stronger and become so significant? Social psychology suggests that two key factors must be present: productivity and cohesiveness. The deer hunting group has both. It lends itself to a plan to which all members can effectively contribute. Individuals have assigned roles: leader, driver or stander. If all do their task, all will share in the success of any member. A deer bagged by any individual is a group accomplishment; productivity and group cohesiveness strengthen each other. As the group continues to hunt together, the backlog of experience, accomplishment, and enjoyment builds. *Eventually the relationship has an intrinsic satisfaction all of its own.*

Traditions, as cited above, are keys to hunter satisfaction. Langenau (1979) comments that satisfaction is difficult to explain when behavior is traditional. Psychologists would also suggest that tradition and ritual can elevate any recurring event from mere play to a meaningful and satisfying lifetime activity. Families are wise to create traditions around seasonal, religious, and other important activities. The same principle applies to hunting. In this context it is no wonder that low user satisfaction is reported when professionals create "new hunts" under management designed conditions.

Any discussion of these results and those of other satisfaction studies must consider the conflicting evidence concerning the association between satisfaction and hunter bag. Bagging of game and the testing and utilization of hunting skills are part of the hunt; however, when a successful hunt is almost totally equated with something in the bag to be obtained under highly competitive conditions, other integral components of the hunt, (i.e., the knowledge of the quarry's life history and habitat requirements, its home area and associated pattern of movements, basic hunting skills, and the thrill and enjoyment of the actual hunt) become a thing of the past. Hunting has become merely a shoot. We suggest that the analysis of the *hunter* (satisfaction) in the harvest and skills context can also be productive for managers and educators. Less experienced hunters do see hunting skills as tools to increase bag, but competence and expertise soon become intrinsically satisfying. As reported earlier, the lower violation rate of waterfowl hunters with retrievers judged to be excellent might have resulted from a lessened need to violate because of the greater satisfactions derived from deep involvement with dog training (Jackson et al. 1979). Data presented in this paper indicate that the rituals surrounding the sport (reloading, fly tying, taxidermy, etc.) are themselves rewarding, often becoming major hobbies in the individual's life. Does harvest itself take on an entirely different meaning through involvement with wildlife over time? The most fortunate and satisfied are those who have the opportunity to experience wildlife year long. Management and educational program models could be created to involve users on more than a seasonal basis.

Summary

Wildlife management that measures its achievement against user satisfaction based on bag and shooting opportunity may be guilty of creating and nurturing the very monster whom we abhor—the slob hunter or fisherman. High quality hunting conditions that encourage and foster hunting skills and satisfaction do exist. They exist where hunting conditions are such that participation in a *total* recreational hunt is supported by agencies; where wildlife management and hunter education programs de-emphasize shooting and emphasize the art of hunting; and where hunter densities are controlled and kept low enough to permit total hunting. The knowledge of how to do it is available and being practiced even on public areas. But these practices will not be enough if they fail to recognize that the real base of recreational user satisfaction is to be found in the *internal* orientation and values of the individual or group. Some of the most important of these dimensions are: expectations, tradition and ritual, group cohesiveness and productivity, and the development of hunting skills. On the basis of these concepts and the research data reported in this paper, the authors conclude that most hunters are basically

susceptible and amenable to hunting programs that emphasize intrinsic values and satisfaction. Wildlife management and hunter education programs should exploit this opportunity to reverse those practices that demean hunting. Recreational hunting has been and will continue to be, to a great extent, that which we make it.

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Improving Management of Chesapeake Bay

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The Chesapeake Bay tidal system (Figure 1) is the largest and most valuable estuary in the nation, with all due respect to the great marshes of the South Atlantic, the fabulous coastal system of Louisiana and other Gulf Coast states, the beautiful estuaries of the West Coast and New England, and even the riches of Alaska. It is the drowned valley of the Susquehanna River with a main stem nearly 200 miles (322 km) long. It receives drainage from 64,000 square miles (165,760 km^2) through the Susquehanna, Potomac, James, Rappahannock, York, Patuxent, Chester, Choptank and about 40 other significant tributaries and hundreds of lesser ones. The principal physical features are shown in Table 1.

The Bay system arose after the last glacial period as the valleys of the Susquehanna and other rivers were flooded during the last 11,000–15,000 years by rise in ocean level as glaciers melted. Geologically, it is young, filling slowly with sediment, and destined to become land with river channels.

The Bay system is biologically rich. It has about 600,000 acres (243,000 ha) of wetlands, includes vast beds where submerged vegetation has sometimes been abundant, and produces the largest crops in the nation of striped bass, oysters, blue crabs, soft-shell clams, American shad, menhaden and, perhaps, sea nettles and tunicates. Two hundred fifty species of fish occur, including those from fresh water and salt water which come to feed, anadromous shad and herrings, and abundant resident estuarine species. Reptiles, mammals and birds are common, and over 2,700 macroscopic species of plants and animals have been identified. However, later papers will show that all is not well with some of the biota. Or with their environment.

Usage of the Bay system is enormous for transportation, for production of food, for recreation, for aesthetic enjoyment, for the placement of wastes and for many other human purposes (Table 2). The problems of damage to the system and of intensive conflict among uses have escalated rapidly as the regional human pop-

Figure 1. The Chesapeake Bay.

Table 1. Physical and biological characteristics of the Chesapeake Bay system (U.S. Army Corps of Engineers 1974; Cronin, L. E., in press; Cronin, W. B., 1971; Lippson 1973).

Physical		
Length	290 kilometers (180 miles)	
Width	8-48 kilometers (5-30 miles)	
Depth	53 meters maximum (175 feet)	
	8.4 meters average open bay (27.6 feet)	
	6.5 meters average including tributaries (21.2 feet)	
Surface area	6,500 square kilometers open bay (2,500 square miles)	
	11,500 square kilometers with tributaries (4,400 square miles)	
Shoreline	13,000 kilometers (8,100 miles)	
Volume	52 billion cubic meters open bay, low tide	
	74 billion cubic meters total, low tide	
Drainage	Area (square miles)	Mean annual flow (cubic feet per second)
Susquehanna (435 miles)	27,510	39,235
Potomac (407 miles)	14,670	13,770
James (434 miles)	10,102	10,945
Rappahannock (184 miles)	2,715	2,940
York (130 miles)	2,660	2,660
Total basin	64,160[a]	76,945
Range in mean annual flow 49,000 (1965)— 131,800 (1972)		
Extreme low flow (week 6 September 1966) 4,720		
Biological		
Plant species	1,220+	
animal species	1,500+	
Total	2,700+	
Wetland area	243,000 hectares (600,000 acres)	

[a]Exclusive of bay and tributaries

ulations developed and as technology and the inventive creation of new chemicals increased. In 1973, the regional population was about 8,000,000 and it is projected to increase to about 12,500,000 by 2000 and 16,300,000 by 2020 (Figures 2 and 3). Projected associated increases in recreation, shipping, fishing, water usage and the generation of electricity are shown in Table 2. They are impressive and disturbing.

It is appropriate to note that the 1973–75 data are facts, but that numbers for 2000 and 2020 are projections, based on specific working assumptions. Each projection may or may not come true, depending on a large group of factors— most especially the variety of governmental decisions and actions which are taken, or are not taken, over the next forty years.

This Special Session was planned with recognition of the record of serious changes, including some declines, within the Chesapeake Bay system and the substantial possibility of further growth in the human population and associated industrial activities.

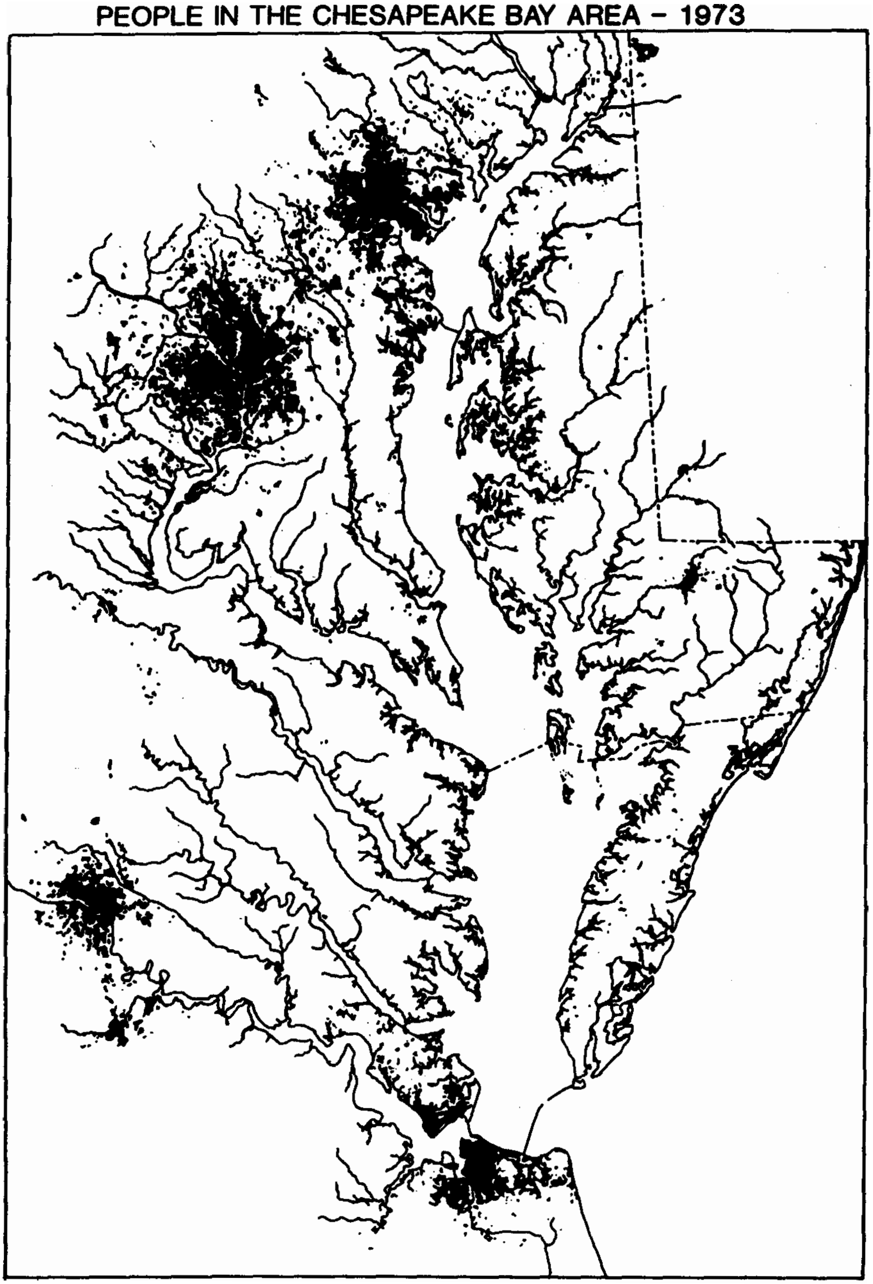

Figure 2. Chesapeake Bay region, indicating land used for residential and commercial activities as of 1973. After U.S. Army Corps of Engineers 1977.

PEOPLE IN THE CHESAPEAKE BAY AREA – ESTIMATES FOR 2020

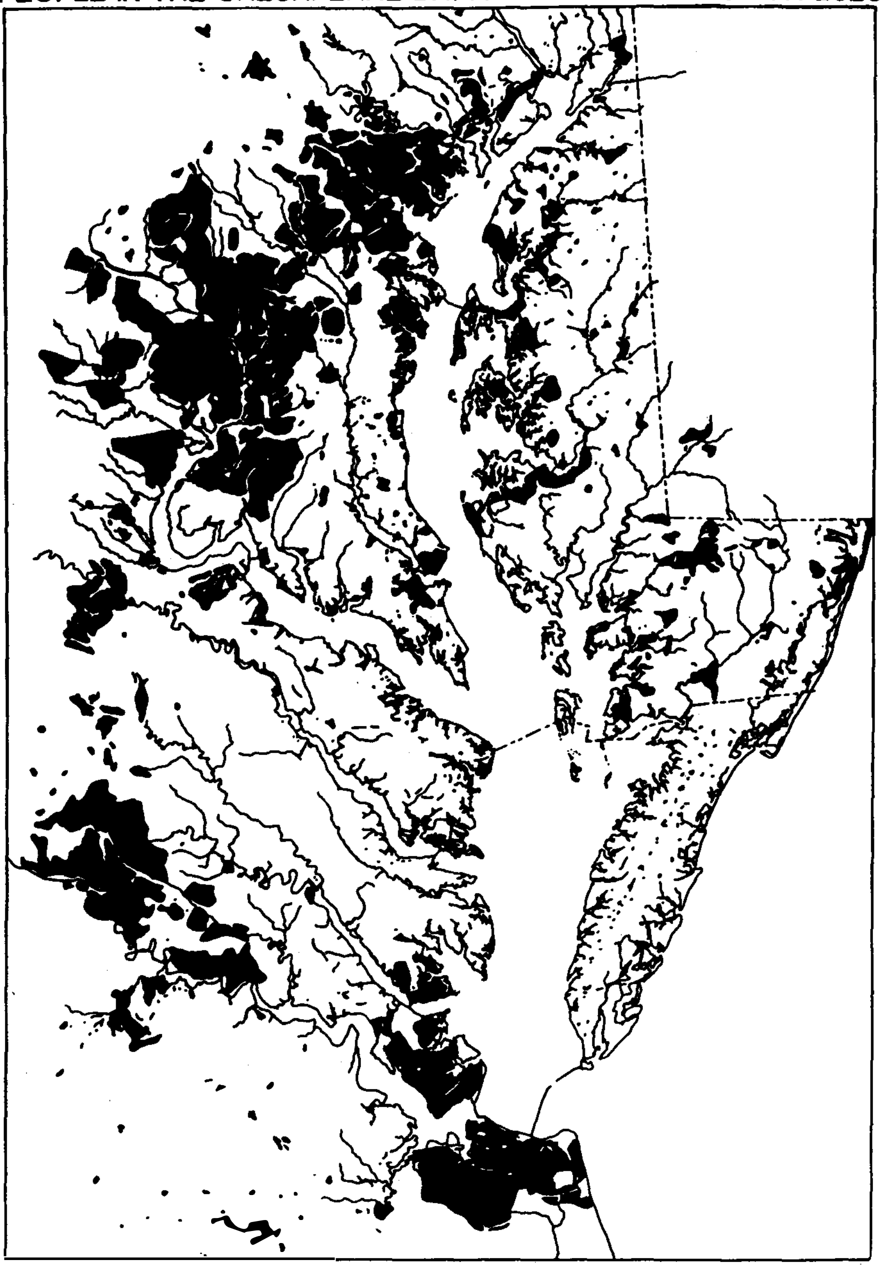

Figure 3. Chesapeake Bay region, indicating land used for residential and commercial activities as projected for 2020. After U.S. Army Corps of Engineers 1977.

Table 2. Projections for the Chesapeake Bay region (U.S. Army Corps of Engineers 1977).

	1970	2020
People (millions)	7.9	× 2.1 (16.3)
Electricity	68 TGMW	× 13.5
Land Use		
Residences		× 2
Industry		× 1.5
Agriculture		× .8
Water use		
Central systems	872 MGD	× 2.7 (2320)
Consumptive use		× 8
Agricultural use		× 4
Water quality		?
Recreation	59 million days	
Boating and sailing		× 5
Swimming		× 4.5
Camping		× 6
Commercial transportation	160 million tons	
Bulk oil		× 2 (Baltimore)
Foreign general cargo		× 6
Flooding	Critical for 31 communities	
Fisheries	565 million pounds $48 million dockside	Catches of all species will exceed maximum sustainable yield

It is exceptionally appropriate and useful to review uses and management of the Chesapeake Bay on the basis of water quality and the biological system. The biological health and success of the Bay is the basis for almost all of its uses—as an aesthetically attractive body of water, as a source of enormous harvests of commercial and recreational species, as the site of other recreational activities and even as an assimilator of considerable quantities of wastes from land and from human activities. If the biological system is seriously disrupted by degraded water quality or other means, we face the possibility of stinking ugly waterways, of poor catches of fish, crabs, oysters for both sport fishermen and commercial fishermen, reduced populations of wildfowl and desired mammals, and an undesirable place to boat, ski or swim. No characteristic is more important or a more useful indicator than the biological state of the Bay (Cronin 1978). Much about that state will be reviewed in subsequent papers.

As a final point in these background comments, I would emphasize, with deep personal satisfaction, that the fundamental unity of the Chesapeake Bay is increasingly recognized. The Bay has long been fractioned between states and among federal regions and districts. Now, it is increasingly regarded by the public, studied by scientists and managed by agencies and by regional cooperative bodies as a single physical, chemical and biological system, with all parts inextricably linked (Cronin, in press).

This glimpse of some aspects of the Chesapeake Bay is a brief prologue to the discussions to follow. We have arranged for review of the past and present trends and of future probabilities for six important components of the Bay system. Then, an experienced and expert assessor of the management of biological systems will consider whether our present approaches to this great resource are sufficient to assure its long-term health and welfare.

We hope that this short but intensive session contributes to achievement of that long-term health and welfare.

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Trends in Water Quality for Chesapeake Bay Relative to Improved Management

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Introduction

The Chesapeake Bay is a moderately stratified estuary characterized by temporally and spatially complex hydrodynamics (Pritchard 1967). As an estuary, the Bay is large—approximately 195 miles (313.8 km) long, with 8,000 miles (12,874) of shoreline and a surface area of about 4,400 square miles (11,396 km^2) including tributaries (Figure 1).

The Bay's size, its location near large population centers, its value as an artery of commerce and a significant contributor to the region and nation's fishery resources, and its high recreational value make the Bay of exceptional interest to people. These characteristics coupled with the widely held view that the Bay and tidal tributaries are threatened by pollution have focused increased attention on the Bay's water quality. In recent years, these perceptions have been reinforced by incidents such as Kepone in the James River sub-estuary, excessive nutrient enrichment leading to large algal biomass and anoxic waters in other areas, the loss of Bay grasses, and the relatively poor status of several fisheries including shad, striped bass, and blue crabs.

In 1976, in response to the above concerns, Congress directed the U.S. Environmental Protection Agency (EPA) to implement the Chesapeake Bay Program (CBP), a five-year program operated at about $5 million annually. Three problem areas were defined for Program consideration: nutrient enrichment, toxic chemicals, and the decline of the Bay grasses. In addition, the Program was charged with examining a range of management options for public consideration. Final reports on the major areas of concern, e.g., nutrients, toxic chemicals, Bay grasses, and management options, will be completed in the fall and winter of 1981.

The objectives of this paper are to review historical trends in water quality in the tidal Bay ecosystem, discuss limitations in those trend data, and suggest how assessing data might be improved upon to facilitate management of the Bay.

Trends and Limitations

Nutrients

Heinle et al. (1980) reviewed the historical information on nutrients and related information, e.g., chlorophyll *a*, Secchi depth, salinity, temperature, rainfall, land use, and population trends. We have drawn heavily on this analysis. The greatest spatial and temporal coverage in data exists for the upper Bay proper covering the region from the Susquehanna flats to Annapolis, the Patuxent, Potomac, and James River estuaries. We cannot review in detail this extensive literature but will try to

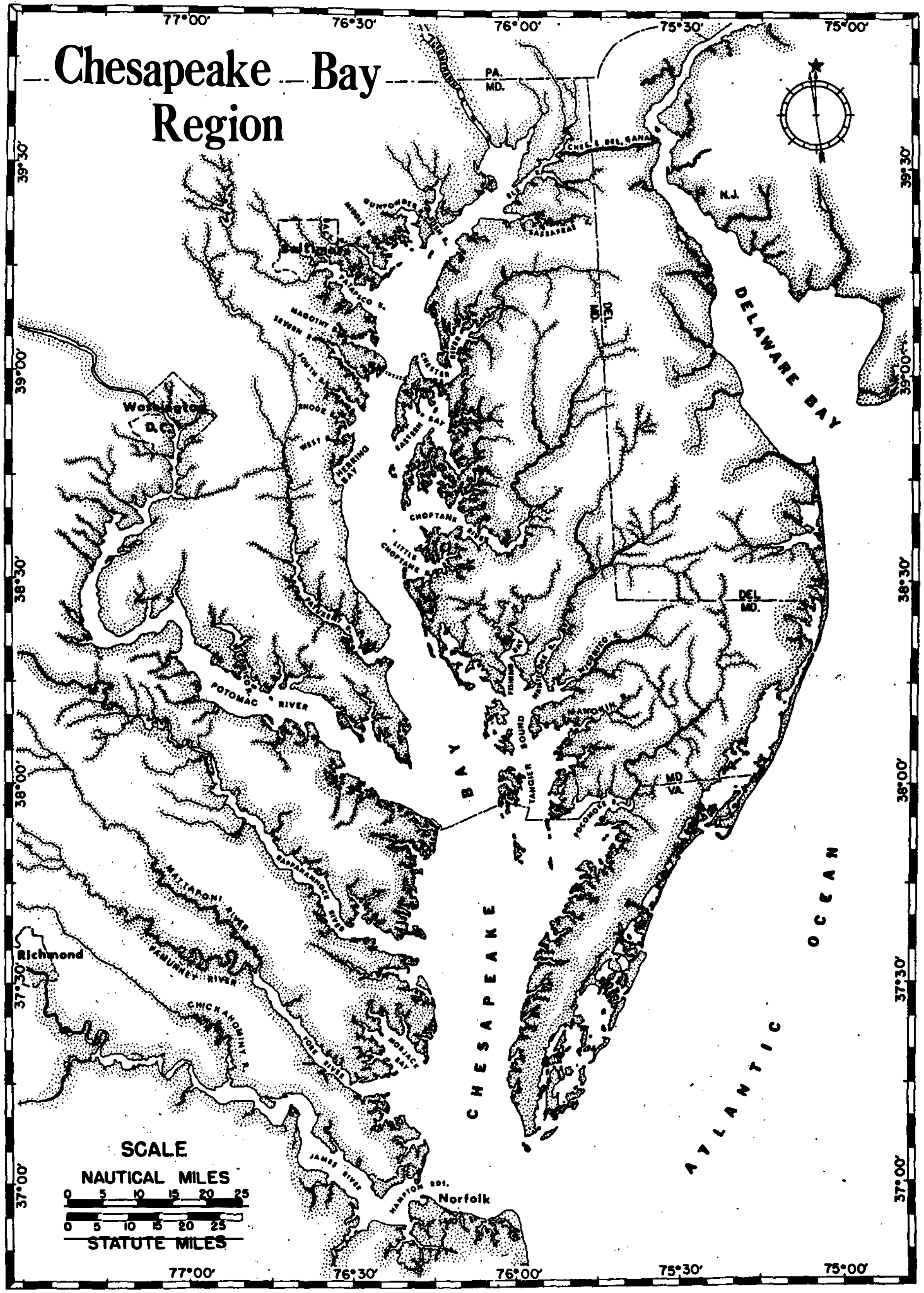

Figure 1. The Chesapeake Bay.

convey the essential features of trends in nutrients, phytoplankton biomass, turbidity, and related water quality information in an abbreviated form.

Inputs. There is no periodic compilation of total nutrient loading to the Chesapeake Bay in which to infer trends. Some information on individual watersheds is available. Brush (1974) summarized all sewage discharges in the Chesapeake Bay basin during 1973. Heinle et al. (1980) estimated the percentage of freshwater that is sewage for several larger tributaries, and confirmed that those tributaries in which some enrichment problems have occurred had the highest percentage of sewage, e.g., 4.8 percent in the Potomac (Table 1). Jaworski (1980) estimated the total nutrient loadings to the Bay for the period 1969 to 1971 from a variety of sources and estimated an annual nutrient budget for nitrogen and phosphorus. Champ et al. (1980) have provided additional information (Figure 2). Estimates made by the above authors could be extended with appropriate assumptions to cover other periods that might permit first order estimates of trends for nutrient inputs from point and nonpoint sources; e.g., forests and marshes, nonpoint sources from agricultural and developed areas, and point sources, principally sewage treatment plants and industrial sources. This would be a major task.

Water Column Concentrations. In many areas of the Chesapeake Bay and tidal tributaries, the effects of nutrient enrichment were well developed before scientific documentation became available. An exception is the Patuxent estuary where studies were undertaken during the late 1930s. Typically, the only nutrient forms measured regularly from the 1930s to the present were othophosphate-phosphorus (PO_4-P) and nitrite (NO_2) and nitrate (NO_3) - nitrogen. Chlorophyll *a*, an indicator of phytoplankton biomass, was first measured quantitatively on a regular basis during the early 1950s. Methods to measure turbidity have varied widely and make comparisons difficult. Thus, these data offer only a weak position from which to interpret the effects of nutrient enrichment or evaluate the significance of trends in the above factors.

Upper Chesapeake Bay (Susquehanna Flats to Annapolis)

The upper Bay changes from spring and fall maximum (PO_4-P) concentrations to maximum concentrations in the summer (Table 2). Typically, maximum NO_3

Table 1. Twenty-seven year average freshwater flow from data of the U.S. Geological Survey annual summaries of stream flow entering Chesapeake Bay (December 1951-1978); point sources of sewage (from Brush 1974) and calculated percent of annual flow that is sewage.[a]

River	27-yr. average flow (cfs)	Point sources of sewage (cfs)	Percent of freshwater that is sewage
Susquehanna	38,800	557	1.4
Patuxent	1,085[b]	41.15	3.8
Potomac	13,900	670	4.8
James	10,100	302	3.0
Chesapeake Bay	75,200	2,034	2.7

[a]From Heinle et al. 1980.
[b]Patuxent flows were taken from the Johns Hopkins University (1966) rather than the U.S. Geological Service data.

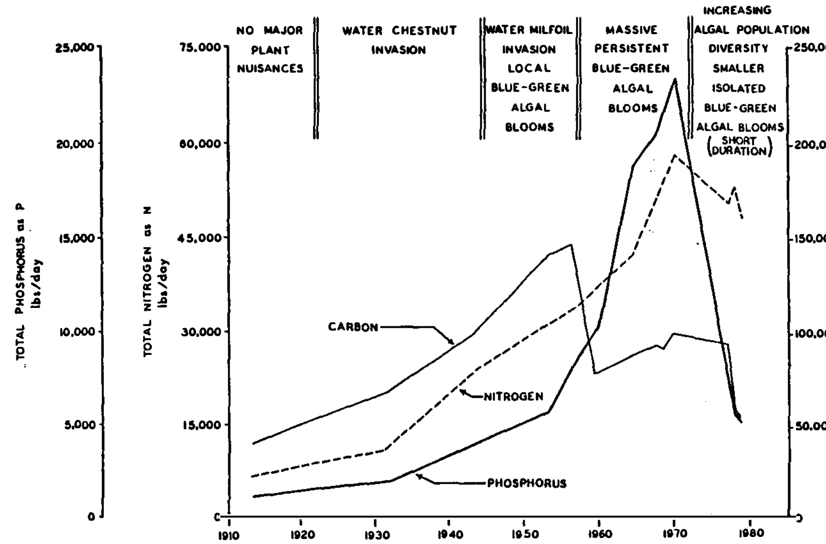

Figure 2. Wastewater nutrient enrichment trends and ecological effects, upper Potomac tidal river system (from Champ et al. 1980).

and NO_2-N concentrations occur in the winter and minimum values occur in the summer. Chlorophyll *a* values generally are highest in the summer and lowest in the winter in this region of the Bay in contrast to occasional or possibly regular annual events of spring peaks in chlorophyll *a* in the lower Bay. Studies during 1949 to 1951 (Hires et al. 1963, Stroup and Wood 1966); 1964 to 1966 (Whaley et al. 1966, Carpenter et al. 1969); 1965 to 1967 (Flemer 1970); 1967 to 1968 (Anonymous 1968, 1971a, 1971b, Marks and Villa 1969, Clark et al. 1973) and 1969 to 1971 (Taylor and Grant 1977) document the major trends. Several more recent papers (Heinle et al. 1980) describe important nutrient-plankton dynamics.

The data suggest that from 1949 to 1964 gradual increases in nutrients led to medium sized phytoplankton standing crops by 1964 to 1965. Between 1966 and 1969 increased standing crops resulted presumably from a continued increase in nutrients. Some bluegreen algae were noted in small tributaries, e.g., Sassafras River. Phytoplankton biomass has apparently reached a "quasi-plateau" and PO_4-P is judged to be in excess, as this nutrient now remains in fairly high concentrations throughout the summer. We suspect that light is now controlling the maximum biomass yield more than nutrients, especially in the turbidity maximum area, a region of high concentration of suspended sediments located at the interface between tidal fresh water and brackish waters. Further evaluation of this hypothesis is expected through the Chesapeake Bay Program's water quality modeling.

Middle Chesapeake Bay (Chesapeake Beach to Smith Point)

This reach of the Bay is characterized by slightly higher levels of PO_4-P in the late 1970s than in the 1930s (Newcombe 1940, Newcombe and Brust 1940, Newcombe and Lang 1939), and chlorophyll *a* levels show a slight increase from 1951 to the late 1970s (Table 2). There is some evidence that the extent and duration of

Table 2. Summary of trends in inorganic phosphate - phosphorus (PO_4-P), nitrite and nitrate-nitrogen ($NO_2 + NO_3 - N$) and chlorophyll *a* for Chesapeake Bay and tidal tributaries. Plus sign (+) represents increase over time, ++ represents significant increase, – sign represents no discernible trend.

	PO_4-P (ug-at l^{-1})	NO_2+ NO_3-N (ug-at l^{-1})	Chlorophyll *a* (ug l^{-1})	Comment
Upper Chesapeake Bay (Susquehanna Flats to Annapolis)	+ Summer from 1949-1951 to 1969-1971 values > from about 0.2-0.5 to 1.0. Summer minimum noted in 1949-1951 but changed to summer maximum.	– Winter/Spring peaks of 80-100 with summer minimums of approx. 1.0 to 10.0. No clear trend.	++ Maximum values by 1965 reached 80 in summer and slight > by summer of 1971. Typically single annual peak in summer, no spring pulse.	D. Flemer (unpubl.) noted occasional bluegreen algae in main stem of Bay in 1965-1966 and single field observation of bluegreen form in Sassafras River. Bluegreens commonly noted by 1971 in many tributaries.
Middle Chesapeake Bay (Chesapeake Beach to Smith Pt. on Potomac River)	+ From 1936 to 1951 values ranged from undetectable to 1.3. By 1964-1966 max. values approx. 2.0 and by mid-1970s values of 2.5 were noted.	Insufficient data for trend. In early 1970s region of fall pulse in NO_2-N.	+ Chlorophyll *a* increased in conc. from 1951 to 1966 with max. values approx. 25 in surface waters, with somewhat higher values in deeper waters. From 1966 to 1977 not changed.	Dissolved O_2 values in deep channel may be depressed for longer periods and over larger reaches of Bay in late 1970s.
Lower Chesapeake Bay (Smith Pt. and seaward)	+ From 1949-1951 to late 1960s and early 1970s see slight increase in concentration, but values mostly less than 1.0.	Insufficient data for trend.	– Data only suggests possible increase over last 25 years.	Region often still shows spring phytoplankton bloom in contrast to upper Bay.

Potomac River			++	
Upper(Woodrow Wilson Br. to U.S. 301 Bridge)	Insufficient data for trend. By 1970 max. values approx. 30 at W.W. Br. and 6 at Indian Head; by late 1970s values show substantial decrease, e.g., at W.W. Bridge values of 1.3 and Indian Head values of 0.3 were common.	Insufficient data for trend. By summer of 1965 values approx. 128 at W.W. Br. and 36 at Indian Head. By summer of 1978, values approx. 60 at W.W. Br. and 70 at Indian Head.	By 1970 max. values approx. 200 or greater at Indian Head with excessive growths of bluegreen algae. By late 1970s max. values about 43 at W.W. Br. and 64 at Indian Head.	In late 1960s anoxic conditions common in bottom waters in summer; slight improvement by late 1970s with occasional late night values possibly reaching 1-2 ppm D.O. (L. Clark, pers. comm.)
Lower			++	
(U.S. 301 to Mouth)	Insufficient data in seaward section of lower area. By 1949-1951 values ranged from 0.0 to 0.3. By 1965-1966 values ranged from 0.04 to 2.6 and by 1970 max. values approx. 6.0 at U.S. 301 Br. and 10.15 at Piney Pt. By 1978 values approx. 2.3 at U.S. 301 Br. and no change by summer 1979 (L. Clark, pers. comm.)	Insufficient data for trend. By summer of 1965 at U.S. 301 Br. values approx. 1.8. By 1970 values here approx. 80 in winter and 12 in summer. At Piney Pt. in summer of 1970, values at trace to 100. Not much change by summer 1978.	No summer values available in 1949-1951. By 1964-1966 values range from 9 to 26 in Aug.-Sept. and slightly higher in deeper waters. By 1970 at U.S. 301 Br. values reach 50-60 and Piney Pt. bloom of 80. By summer of 1978 values approx. 12-15.	In summer of 1977 deep channel in lower river showed D.O. values about 1.0 ppm.
Patuxent River	++	++	++	
Upper (Turbidity max.-approx. Lower Marlboro to Benedict Br.)	From 1936-1939 values approx. 1.0. By 1968 and thereafter values ranged between 1 and 15.	From 1936 to 1965 values approx. 1-10 and thereafter many values range between 50 and 100.	Max. summer values increase from early 1960s to late 1960s, from about 10-20 to 40-50 with occasionally higher values. In tidal fresh waters values approx. 80-100. Winter values show some increase.	Apparently D.O. levels not serious problem.

Table 2. (Continued)

	PO_4-P (ug-at l^{-1})	NO_2+NO_3-N (ug-at l^{-1})	Chlorophyll *a* (ug l^{-1})	Comment
Lower (Benedict Br. to Mouth)	++ From 1936-1939 values usually approx. 2.0 with max. values in summer in contrast to upper Bay. By summer of 1968 and thereafter values reach 3.5 and winter values approx. 0.2 to 1.0.	++ From 1936-1965 values approx. 1 to 5 and 1968 and thereafter values in winter approx. 50; summer values dropping to about 1.0. In mid-1970s note NO_2-N peaks in fall at Benedict Bridge.	++ Max. summer values increase from early 1960s to late 1960s from about 5-10 to 30-40. By late 1970s max. values occasionally up to 100.	Bottom waters show D.O. less than 1.0 ppm at times in summer by mid- to late 1970s. Some surface values approx. 2.0 ppm.
James River				
Upper (approx. Hopewell to Jamestown Is.)	Data started too late for trend.	Data started too late for trend.	++ In 1965-1966 max. values approx. 50-80 in tidal freshwater and 20-50 in mid-estuary.	Some low D.O. values noted in tidal freshwater in mid-1960s.
Lower (Jamestown Is. to Old Pt. Comfort)	+ In 1949-1951 max. values approx. 1.0. By 1965-1966 max. values approx. 1.0 to 1.5 and by 1973-1975 max. values approx. 2.0 to 3.0.	+(?) In 1965-1966 max. values approx. 40 and by 1973 values ranged between 4-6 with occasionally 40-60 high values.	+ In 1949-1951 max. values approx. 10. By 1965-1966 max. values approx. 15-20 with indication of spring and fall bloom. By 1973-1975 values similar to 1965-1966.	Note: High nutrient levels not reflected in Chlorophyll *a* levels.

the deep channel anoxia may have increased since 1965; however, the mid-1960s were relatively dry years, conditions which would permit greater reaeration and mixing of oxygen in the surface waters with deep waters (Taft et al. 1980).

The nitrogen data are difficult to interpret even though some increases over time have occurred (Table 2). Nitrate-N levels generally decrease with an increase in salinity, an indication that physical dilution is the dominant process (Carpenter et al. 1969). McCarthy et al. (1977) observed relatively high concentrations of NO_2-N in this region of the Bay during the fall of 1971 to 1972, a condition probably resulting from the oxidation of ammonia-N (NH_4-N) accumulated below the pycnocline. Why oxidation was not completed to NO_3-N is poorly understood. Earlier data of the Chesapeake Bay Institute (CBI) for 1964 to 1966 did not show unusually high NO_2-N values. The relative control of nitrogen versus phosphorus is speculative at this time. Ancillary information suggests that nitrogen may be in short supply, as Flemer and Biggs (1971) noted that suspended particulate organic material suffered a relative loss of nitrogen with respect to carbon.

This region of the Bay has historical Secchi disc data from the late 1930s which are difficult to interpret since the correlation is poor between Secchi depth and chlorophyll *a* values (Heinle et al. 1980).

Lower Chesapeake Bay (Smith Point and Seaward)

Phosphate-P concentrations show a slight increase from CBI cruises from 1949 to 1951 to the late 1960s and early 1970s, and some evidence suggests that chlorophyll *a* increased slightly during this period (Smith et al. 1976, Patten et al. 1963, Fleischer et al. 1976). Nitrogen has not been measured long enough to establish trends; however, McCarthy et al. (1977) described seasonal patterns of nitrogen concentrations and use by phytoplankton. Chlorophyll *a* in some years shows a spring peak in concentrations with peak values approaching 20 to 25 ugl^{-1}. Most values approximate 10 ugl^{-1} during the remainder of the year. Further increases in PO_4-P are not expected to lead to further increases in chlorophyll *a*, as nitrogen is believed to be a more important controlling nutrient in higher saline waters (Webb 1980). The lack of historical data on forms of nitrogen other than NO_2 and NO_3-N is clearly shown to limit a thorough interpretation of nutrient-phytoplankton trends in the lower Bay.

Eastern Shore Tributaries

Some data are available for the Chester, Choptank, and Miles rivers and Eastern Bay resulting from CBI studies in 1949 to 1951 and 1964 to 1966, and EPA (Anonymous 1971b) studied the Choptank in 1970. Though distant from large metropolitan areas, these tributaries have shown some increases in PO_4-P and chlorophyll *a*, but no clear trend is evident for nitrogen. Since the circulation of those tributaries is probably dominated by the Bay proper, it is difficult to separate the influence of changes in the Bay from internal tributary dynamics.

Magothy, Severn, and South Rivers

These tributaries, located near Annapolis, apparently experienced relatively high concentrations of PO_4-P and chlorophyll *a* in their lower reaches by the time of the earliest survey conducted by CBI in 1964 to 1966 (Hires et al. 1963, Stroup and Wood 1966). Chlorophyll *a* and PO_4-P have increased in the upstream reaches of these tributaries (Anonymous 1971b). By 1970, concentrations of PO_4-P up to 4.6 ug at l^{-1} and chlorophyll *a* values from 50 to 100 ugl^{-1} were observed in the Severn River. Nitrate and NO_2-N show no clear trend but tend to correlate with concentrations found in the upper Bay (Heinle et al. 1980).

Patuxent River

This subestuary has been surveyed extensively as indicated by 25 major reports given in Table C-4 of Heinle et al. (1980). Mihursky and Boynton (1978) summarized much of the water quality data. There have been increases in the maximum concentrations of major nutrients, increases in the concentrations of chlorophyll *a* and associated rates of phytoplanktonic photosynthesis, decreases in water transparency and dissolved oxygen (especially in deeper waters seaward of the turbidity maximum which approximates the region of the estuary near Chalk Point). Table 2 summarizes the major trends, and the extensive literature is cited in the above references.

Ulanowicz and Flemer (1978) indicated a close coupling between primary production and the rates of disappearance of nitrogen in October, and evidence suggests that nitrogen may play an important role in controlling phytoplankton biomass yield in the lower estuary. Photosynthesis integrated over depth in the upstream, more turbid areas is probably light limited much of the year. Further work on the nutrient-phytoplankton dynamics is under study by Dr. Donald O'Connor, Manhattan College; the Chesapeake Bay Program water quality modeling will focus on the Patuxent.

Potomac River

The Potomac, near Washington, received early attention regarding water quality (Cumming et al. 1916), and the river has been studied with varying intensity and coverage since then. Early efforts focused on Biochemical Oxygen Demand problems in the tidal freshwaters (Wolman 1971). The Chesapeake Bay Institute in 1964 to 1965 was the first to study water quality from tidal freshwater to the river mouth. By then, chlorophyll *a* levels of 80 to 200 ugl^{-1} were common. Additional data are provided by Jaworski et al. (1972) covering 1969 and 1970 and Clark et al. (1980). Table 2 summarizes the historical trends and Figure 2 characterizes some biological changes in plant species. The effectiveness of phosphorus removal at the Blue Plains sewage treatment plant was reviewed by Villa et al. (1977). Concentrations of nitrogen in the river are still high and chlorophyll *a* levels also remain high, although the surface bluegreen form, *Anacystis* sp. was replaced by a filamentous bluegreen that is better dispersed in the water column. Some improvement in dissolved oxygen levels has been observed (L. Clark, pers. comm.).

James River

As in the upper Potomac, significant water quality changes had already occurred by the time of the study by Brehmer and Haltiwanger (1966). By 1965 to 1966 chlorophyll *a* levels in the tidal freshwater James were already 50 to 80 ugl^{-1}, clearly showing the effects of high enrichment.

In the lower estuary, significant increases have occurred in PO_4-P and NO_2 + NO_3-N concentrations since 1965 (Adams et al. 1975) (Table 2). Surprisingly, chlorophyll *a* levels approximate those reported for 1965 to 1966. Heinle et al. (1980) attempt to explain this phenomenon based on grazing pressure. Recent increases in the catch of menhaden, a major grazer, is plausible but further work is needed to verify this hypothesis.

Some of the smaller tributaries to the Bay in the Hampton Roads - Norfolk area have been studied in recent years (Neilson 1978). Many of these rivers receive large volumes of runoff relative to their respective volumes, and dense algal blooms have resulted during periods of low dissolved oxygen as in the Elizabeth River.

York and Rappahannock Rivers

Compared with the limited data available in the Chesapeake Bay Institute reports for 1949 to 1951 on PO_4-P and chlorophyll *a*, both of these rivers have shown increases in recent years in these factors. Insufficient data are available to establish trends for concentrations of nitrogen. Low levels of dissolved oxygen have been observed in the seaward reaches of the York River in recent years (Haas 1977, Webb and D'Elia 1980). These low levels of dissolved oxygen were not noted in the early work of the Chesapeake Bay Institute during 1949 to 1951. In recent years these tributaries have shown dense blooms of dinoflagellates, a condition not reported in earlier work.

Toxic Chemicals

Inputs. There is no comprehensive inventory of actual concentrations of toxic chemicals, which include a number of metals and organic forms, introduced into the Bay and tidal tributaries. Thus, little information is available from which to infer trends. The present EPA National Pollution Discharge Elimination System (NPDES) permitting process provides a mechanism by which just a very small fraction of all toxic compounds are monitored and regulated. These compounds are very arbitrarily placed on a discharge permit when they are generally believed to be found in a particular effluent (industrial and municipal). This present practice provides a limited assessment and control of toxics from industrial and municipal sources. Inventories of industrial processes give only a range of what type of material might be expected to appear in an effluent.

Potentially toxic materials may have a number of sources, e.g., sewage treatment plant effluents, industrial discharges including power plants, atmospheric inputs, and non-point source runoff from agriculture, forests, and urban areas.

Ambient Concentrations. There is relatively little published information on toxic materials in the Bay and tidal tributaries from which to assess trends. More information for metals than organic materials exists, probably the result of the difficulty and expense in measuring organic compounds available in environmental samples.

The limited available data concerning the water column are often so variable that it is difficult to infer trends resulting from hydrologic conditions. An example of the magnitude of the variability is evident in the U.S. Geological Survey data collected at the Conowingo Dam on the Susquehanna River (Lang and Grason 1980). On October 31, 1979 the total recoverable lead concentration in the water was 7 ppb and 13 days later it was 1800 ppb. This study also demonstrates seasonal fluctuation in the concentrations of toxic chemicals.

The concentration of toxic substances in sediments is probably the most reliable data for establishing trends. These data must be interpreted with care, because some studies have homogenized several feet of sediment (Cronin et al. 1974); such bulk analyses are often done when the objective is to estimate the amount of toxic material available for a channel dredging project. Such data have limited value in establishing trends. Table 3 lists the sediment concentrations of several metals of some Chesapeake Bay tributaries. Considerable variation exists in these data. Some recent information on heavy metals from the Bay proper is summarized in Table 4.

An example of trend information for selected metals from Baltimore Harbor is shown in Figure 3 (U.S. EPA 1977). With the exception of mercury, all metals showed an increase in concentration from 7 ft. (2.1 m) up to 0.5 ft (0.15 m). This increase can probably be attributed to industrialization. The decrease in the top 2 inches (5.1 cm) may be due to increased regulation of industrial effluents, increased pollution control technology or, at least theoretically, the influx of "clean" sediment. Unfortunately, no dating was performed on these sediment cores.

Other data are available from the lower Bay. U.S. EPA STORET data, a computer base, show a downward trend in zinc at two stations in the Elizabeth River. Unpublished EPA air quality data show a downward trend in cadmium and

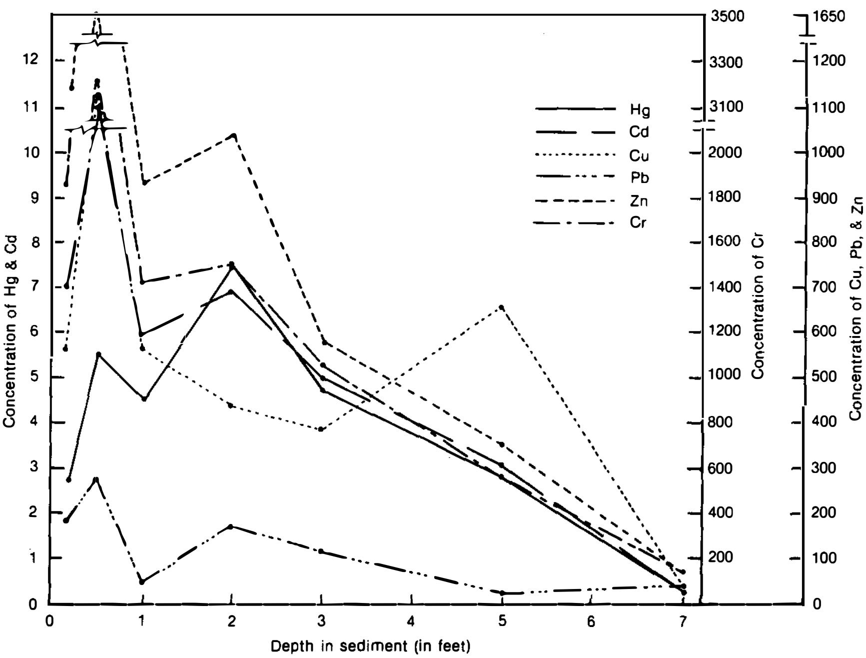

Figure 3. Concentrations of six metals in inner Baltimore Harbor sediments (in mg/kg). Adapted from U.S. Environmental Protection Agency 1977.

Table 3. Metals in sediments of Chesapeake Bay tributaries (in ppm).

River	Sediment depth	*Cd* Hi	*Cd* Lo	*Cr* Hi	*Cr* Lo	*Cu* Hi	*Cu* Lo	*Hg* Hi	*Hg* Lo	*Pb* Hi	*Pb* Lo	*Zn* Hi	*Zn* Lo	Reference
Elizabeth	5-15 cm	26	<1	110	9	395	<2	2.73	<0.01	382	<3	2380	38	a
Potomac	?	0.60	0	75.85	5.93	61.88	7.90			85.83	0	349.3	54.3	b
James	Upper 1cm							2.60	0.40					c
York	Upper 1cm							2.02	1.03					c
Rappahannock	Upper 1cm							1.70	0.42					c
Patapsco	10 ft. Avg	111	1	1848	23	1661	14	3.30	0.04	941	14	1712	91	d
Patapsco	5-15 cm	654	<1	5745	10	2926	<1	12.20	<0.01	13,890	<1	6040	31	e
	30-40 cm	9	<1	2102	14	2000	2	10.98	<0.01	2218	<1	3730	48	e

a. Johnson and Villa 1976
b. Jaworski et al. 1971
c. Huggett et al. 1971
d. U.S. Environmental Protection Agency 1977
e. Villa and Johnson 1974

Table 4. Concentration ranges of selected heavy metals in the main bay.

Parameter	Concentrations				
	Sediment mg/kg	Surface Sediment (Fluid Mud) ug/g	Susp. Sediment (Dry Weight) ug/g	ug/l	References
Cadmium	<1	<.065-1.4	0.24-210	.0042-1.8	a, b, c
Chromium	18-42				c
Copper	<1-85	.87-44	18-520	.13-6.2	a, b, c
Mercury	<.01-.31	<.05	.36-42	.021-.47	b, c
Manganese	218-1900	58-3,600	200-4,000	1.1-930	a, b, c
Nickel	5-75	2.3-80	16-770	.16-6.3	a, b, c
Lead	9-86	2.9-99	17-670	.10-7.8	b, c
Zinc	33-420	13-710	160-7,100	.78-80	a, b, c

a. Cronin et al. 1974
b. Villa and Johnson 1974
c. Harris et al. 1980

lead in the air over Baltimore since 1977. In addition, nationwide atmospheric concentrations of the organic pollutant, benzo (a) pyrene have decreased over the past decade (Faoro and Manning 1981). The relationship of atmospheric sources of toxic chemicals to the Bay environment is poorly understood but is under study by the Chesapeake Bay Program.

The results of a sediment core study done in the Rappahannock River showed no clear trend with little variability over depth in mercury concentrations (Bender et al. 1972). Concentrations ranged from about 0.05 to 0.17 ppm over a depth of zero to 130 cm.

The paucity of published information on synthetic organic chemicals is noteworthy with the exception of Kepone found in the James River (U.S. EPA 1978). A recent study of phthalate ester plasticizers in the sediments of the upper Bay shows some interesting trends (Peterson 1980). These compounds are generally considered relatively low in toxicity; however, they are ubiquitous in the aquatic environment, especially in industrialized regions. Peterson is preparing for publication information which correlates the annual production of synthetic organic chemicals from 1949 to 1979 with selected phthalate esters and the concentration of these esters in the sediments of the upper Bay with their industrial production.

In the above study polycyclic aromatic hydrocarbons (PAH's) were analyzed from sediment cores. The trend observed in benzo (a) anthracene + chrysene concentrations generally increased from the early 1880s to about 1915 and then showed a general decline to the present. A slight increase was noted during the early 1940s with a fairly precipitous drop in levels about 1965. This pattern is not limited just to the United States and seems to correlate with the production of fossil fuels (Peterson 1980).

Assessing Nutrient and Toxic Chemicals—A View to the Future

Existing information has been used to describe the historical pattern, up to the present, for nutrients and toxic chemicals. Though better information is available for nutrients than toxic chemicals, even the former becomes especially scattered prior to the early 1960s. In order to improve our ability to make future projections for nutrients, the Chesapeake Bay Program is developing a computer-based water quality model that will incorporate ecosystem processes including algal physiological uptake kinetics, grazing, and hydrodynamics, and predict the effects of changes on dissolved oxygen from variable rates of nutrient input to the Bay and tidal sub-estuaries. This tool will help evaluate the relative importance of nitrogen, phosphorus, light, and other factors as they effect changes in phytoplankton biomass and associated changes in dissolved oxygen, especially in the present "hot-spot" areas in or near tidal freshwaters and in the deep channels of the Bay and tidal tributaries. Low levels of dissolved oxygen have been apparently characteristic of the deep channels as a consequence of natural processes and our water quality model will help us assess whether increased nutrients will exacerbate the problem. Though we have focused on dissolved oxygen, in the long term there is a great need to consider food web implications of an increased nutrient supply.

Thus, we feel that it is inappropriate to make simple extrapolations of present trend lines as a basis for assessing future conditions, i.e., year 2000. Based on the Corps of Engineers Future Conditions Report (Corps of Engineers 1977), existing nutrient problems are likely to be magnified unless controls and management practices are given further consideration.

In the case of toxic chemicals, existing data severely limit an assessment of past conditions. The Chesapeake Bay Program will contribute substantially to an inventory of the distribution of toxic substances in the Bay and selected sub-estuaries. Information on the concentrations of toxic chemicals, hydrodynamics, physical characteristics of bottom sediments, and associated animal-sediment relationships will improve our ability to characterize the mechanisms responsible for the sediments to serve as a medium of transport and fate for toxic chemicals. This information, coupled with data on land use practices, e.g., industrial and agricultural development, and urbanization will be used to make future projections.

Management Considerations

From the outset of the Chesapeake Bay Program, the following question has been asked: "How does one interpret trends in water quality for the Chesapeake Bay, particularly with respect to improved management?" To address this issue, we explored what mechanisms and procedures from other sources, both within the United States and internationally, have been used to address similar questions about estuarine management. This led us to the Thames River Authority (TRA), Great Lakes International Joint Commission, San Francisco Bay Authority, and others.

The fundamental hypothesis was that large ecosystems are too diverse and complex to either study or manage as one unit. The TRA and other groups developed systematic methods to break or segment the ecosystem into sub-units based upon physical, chemical, and biological parameters. They used basic water quality parameter concentrations to assess the relative condition of each segment along a degradation continuum and suggested alternative approaches to meeting certain water quality objectives. They *at no time* forgot that any activity in one particular segment directly impacted several other segments, and this caveat was factored into all their decisions. We will do likewise.

Not surprisingly, we believe that a segmentation approach, as a management tool, would be a valuable asset to managing the Bay. The need for segmentation or zoning of the Bay based upon natural processes and uses has been discussed by Schubel (1975) and Ulanowicz and Neilson (1974) used the Patuxent estuary to show the value of segmentation as a method of spatially aggregating estuarine models for simplification with minimal loss of information. Specifically, segmentation can provide the following practical benefits:

1. assist in the integration of scientific data both from the Bay Program and elsewhere;
2. assist in providing better trend analysis of past water quality data and highlighting future data needs;
3. provide a framework for establishment of water quality objectives;
4. facilitate public choice in making decisions related to management of the Bay; and
5. provide a framework for monitoring changes in the future and insuring accountability for management of Chesapeake Bay.

How Do These Benefits Come About?

We believe that an adjunct to understanding the assimilative capacity of the Bay and tidal sub-estuaries—a key feature of understanding the benefits to managing the Bay—is a fundamental understanding of the ecological structure and functional relationships of the system. Without a broad conceptual framework, really an ecosystem perspective, we argue that it is difficult to relate water quality trends to effects.

For comparative purposes, it is important to comprehend the components of the estuarine system and understand how these components interact at a scale that is scientifically meaningful yet is not lost in the potentially great ecological detail and complexity that we know exists in the Bay. Thus, a desirable framework would permit the estuarine ecosystem to be divided into comparable units from an analytical perspective and represent the continuity of system processes.

The principal criteria for segmentation should be based upon a geophysical basis since these factors set the boundaries for chemical and biological features. For example, salinity and hydrographic structure are useful parameters since salinity is widely recognized as a key parameter in determining the nature and extent of biological communities and the hydrographic structure characterizes the potential for materials (e.g., nutrients, dissolved oxygen, and toxic chemicals) and organisms (e.g., true plankton, eggs, and larvae of numerous Bay fishes) to be transported in the system.

Thus, a first level of analysis might lead to segments that correspond to the following classification: tidal freshwater, turbidity maximum, region of two-layered circulation, etc. Each of these regions shows similar dominant biological features, e.g., the tidal freshwater is the spawning area for several anadromous fishes and when under excessive nutrient supply, responds with "nuisance" blue-green algae. The turbidity maximum is believed to be an important nursery area for numerous juvenile species and probably is a site for maximum exchange of toxic materials that strongly adsorb to fine silts and clays. The description could be expanded; however, our purpose is to be indicative and not all-inclusive at this time.

Therefore, segmentation as a management tool will have its greatest utility when it is based upon a fundamental understanding of the estuarine system. The voluminous data from the Bay can be better interpreted with some systematic framework such as segments. The segmentation framework likewise aids in assessing water quality trends since we are more specific on "trends in what areas." The data base for nutrients was organized within the framework of segmentation (Heinle et al. 1980). Likewise, this rationale extends to the setting of water quality objectives that can be targeted for specific areas. To the extent that segmentation provides a way to make meaningful comparisons within potentially a very complex estuarine system, we feel that public choice should be facilitated in making management decisions.

How Does Segmentation Assist Directly in Management Actions?

We feel that to manage any system, at least five basic activities are necessary. First, establish specific goals or targets. As explained in the above rationale, goals whose bases are rooted in a scientific framework are more likely to have realistic expectations. Second, determine who will be accountable for meeting the goals or targets. This may be largely determined through administrative procedures; however, explicit goals can be more clearly stated when they are more closely tied to expectations based upon a sound conceptual framework. This should help the public evaluate more objectively the role and effectiveness of the identified agency(s). Third, define existing conditions or status as to clarify how far away from attainment the goals are. Again, this activity is aided by focusing on comparable areas. Fourth, develop solution alternatives or plans of action for reaching particular goals. We assume that a meaningful compartmentalization of the Bay will permit management to set realistic and achievable objectives that are perceived as practical alternatives—not objectives necessarily across the board for this complex system. Fifth, implement plans of action to maintain constant monitoring and reporting of progress toward goals to interested parties. The reasonableness of this action is predicated on the previous actions.

The EPA Chesapeake Bay Program is concentrating on defining existing conditions with respect to toxics, nutrients, and Bay grasses for the segments and developing solutions(s) for reaching water quality goals and objectives in selected segments. Recommendations will be made on approaches and parameters to be used to monitor progress of the Bay in the future. These data will provide a baseline for effective public choice among the possible water quality objectives. In addition, we feel that the baseline status analysis by segment is only the beginning. In the future, the appropriate responsible institutional body should:

1. prepare an annual updated status report using the agreed upon water quality parameters, and
2. prepare Bay plans of action(s) for changing the status of a particular segment.

Segmentation Process

We have highlighted the benefits of and need for a systematic approach but have not specified exactly what is included. In summary, the segmentation process includes:

1. dividing the ecosystem into sensible sub-units, based principally upon physical criteria, and secondarily on chemical and biological indicators;
2. deciding what water quality parameters should be used to assess the health of a segment;
3. assessing water quality data along segments, modifying segments as necessary;
4. by using water quality parameters as indicators, attempting linkages to biota and water quality uses; and
5. identifying management solutions necessary to reach certain water quality objectives (determined by public choice process).

We currently anticipate identifying some 15–20 segments and then using parameters such as salinity, dissolved oxygen, phosphorus, chlorophyll *a*, trace metals, sediment data, and other information to assess the condition of each segment along a degradation continuum. This will also highlight differences among segments with similar physical characteristics and relate all assessments to uses which are allowable and/or precluded under each condition. The categories of "uses" might be as follows:

1. water that can support all or most indigeneous species;
2. water that can support some indigeneous species but not selected, sensitive ones;
3. water that can support contact recreation (boating, skiing);
4. water that meets swimmable/fishable requirements; and
5. water that cannot support above uses but still has capacity for industrial wastes and can serve as a transportation medium.

From this information we can begin to determine the action necessary to control water quality problems in the segments and to reach certain desired water quality objectives, i.e., enhancement, degradation, non-degradation, etc. We must stress that the choice among water quality objectives, as well as among solutions to reach them, is a *public choice*. The data from our program will facilitate these choices. The actual implementation will be undertaken through existing agencies at the federal and state level(s). We have worked with and through these groups throughout our study. The solutions will involve going up the tributary and changing land use practices. Here is where the trade-off among point and nonpoint source pollutants will occur.

Acknowledgements

We especially thank Elizabeth Macalaster of our staff for helpful editorial comments.

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Toxic Substances in the Chesapeake Bay Estuary

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Introduction

The Chesapeake Bay is a geologically young estuarine system, born less than 10,000 years ago when the Atlantic Ocean, rising in response to meltwaters from receding Pleistocene glaciers, began to flood the valleys of the rivers draining the east coast of the North American continent. By approximately 3,000 years ago, tidal waters were beginning to encroach on the present mouth of the Susquehanna River at Havre de Grace and the estuarine geometry was probably quite similar to that which we observe today. The flooding process did not stop then, but the rate of sea level rise decreased. Even today, the flooding continues at approximately 1.6 mm/year in the Chesapeake Bay area (Nichols 1972). This rate of sea level rise is larger than the world-wide average and reflects a local tectonic component in addition to that caused by the increase in volume of sea waters from melting ice caps.

Estuaries form a buffer zone between freshwater rivers and the sea. They behave as very efficient sediment traps for particulate material carried by the rivers and by the inflow of saline marine bottom waters through their mouths. The sediment that accumulates in estuaries is commonly a mixture of river borne terrestrial debris derived from weathering and erosion of the tributary watersheds and coastal marine sediment derived from the continental shelf (Mead 1969, Hathaway 1972). From a geologic perspective, estuaries are very ephemeral features, quickly filling with sediment from these sources. The lifespan of an estuary is a function of the rate of change in sea level vs. the rate of accumulation of sediment. In the Chesapeake Bay, the continuing rise of sea level partially compensates for the rate of accumulation of sediments and the net effect is a prolongation of the lifespan of the system. The estuary, however, is a dynamic system, undergoing continuous evolutionary changes which will ultimately lead to its destruction through infilling with sediment.

The Chesapeake Bay began to experience impacts, in addition to those caused by natural processes, from the time of first European settlement along its shores. Clearing of land for agriculture and development has greatly accelerated the rate of erosion in the adjacent land areas and increased the amount of sediment delivered to the estuary by its tributary rivers. Perhaps an even more serious impact is related to the tremendous technological advances that have been made through the years. Man has been exceedingly ingenious in synthesizing and producing a myriad of new chemical compounds, and in finding uses for an increasing variety of metals and, more recently, radionuclides. These substances enter the environment through waste discharges and other disposal practices (e.g., industrial discharges, sewage effluents, land fills), by direct applications for specific purposes

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(e.g., herbicides, pesticides, fertilizers) and via atmospheric pathways (e.g. automotive exhausts, combustion of oil, coal and wood, incineration of refuse, fugitive dusts from storage or disposal sites, bomb testing). It is now clear that many of the substances that were either purposely or inadvertently released to the environment are displaying unanticipated adverse effects on the biosphere. Historically, estuaries have been favored localities for siting industries, power plants and sewage treatment facilities. They provide an abundant supply of water for industrial processes and for cooling power plants. They are convenient conduits for the disposal of a broad spectrum of wastes. And they provide direct accessibility to marine transportation of raw materials and finished products. As a consequence, estuaries have borne the brunt of man's activities. The Chesapeake Bay is no exception.

Toxic substances represent an obvious threat to the stability and continued use of Chesapeake Bay resources. Recognition of the role these substances play in determining the environmental quality and ecological health of the Bay system requires a thorough understanding of chemical, physical, and biological dynamics that constitutes the total estuarine system. Definitive information on the sources, pathways, and fate of toxic substances is scarce and, where available, usually limited to specialized problems in restricted areas. In 1975, the Environmental Protection Agency initiated a special program, the Chesapeake Bay Program, to begin to address the role of toxic substances in the estuary in a comprehensive and integrated fashion. The following discussion is a brief description of the Chesapeake Bay Program toxic substances investigation including some of the findings that are beginning to emerge.

Two classes of materials, toxic substances and sediment, pose the greatest threat to the environmental well being of the estuarine system. These materials are intimately related in that many toxic substances, inorganic and organic, associate strongly with sediment via physico-chemical mechanisms. As a consequence, the sediment accumulating on the bottom is the largest reservoir of toxic materials in the estuary (Bricker and Troup 1975).

Sediments

The sediments that accumulate in Chesapeake Bay are important for a number of reasons. From a physical standpoint, sediments tend to fill in channels and harbors and thus create a need for periodic dredging in order to maintain these facilities for their intended purpose. Dredging, in turn, requires disposal sites for placement of the material removed. Appropriate handling techniques and disposal site characteristics depend upon the chemical components and physical properties of the spoil. Suspended sediment creates turbidity which decreases the depth of light penetration and may also affect its spectral distribution. The decrease in intensity and shift in spectral qualities may adversely affect aquatic plants. Large concentrations of suspended sediment tend to clog the gills and filtering apparatus of filter feeders causing impairment or death. Rapid sedimentation may cause burial and smothering of benthic fauna and flora.

In the absence of sediments, however, the estuary would not be the fertile and productive environment that it is. Sediments form a substrate upon which rooted aquatic plants grow; they provide a habitat for burrowing benthic organisms; they are a source of nutrients for benthic flora and fauna. Sediments also carry with them metals derived from natural weathering and erosion processes and those introduced by man. Many of these metals are essential to maintain a healthy biota, but in excess are toxic. In addition, sediments are a vehicle for the transport and localization of a large number of the anthropogenic organic compounds that enter the aquatic environment (Olsen 1979). Both inorganic and organic toxic substances have a great affinity for particulate matter of small size and large surface area. Sites of accumulation of sediments possessing these physical characteristics usually contain significantly higher concentration of metals and organic compounds than sites of accumulation of sediments of sand size or larger. Sediments thus play a major role in the transport and distribution of toxic materials in the estuary.

No systematic study of toxic materials in the Chesapeake Bay had been attempted until the Environmental Protection Agency Chesapeake Bay Program was initiated in 1975. In planning that program, it was concluded that any toxic substances discharged into the Bay and its tributaries could have direct impact during their residence time dissolved in the water. However, because of the rapid water movement and concomitant dilution, these effects would be short lived. The most serious potential problems were identified as those associated with toxic substances that accumulate in the sediment and/or biota. These substances have a much longer residence time in the system and may also build up to very high concentrations through sediment sorption mechanisms or bioaccumulation. For these reasons, knowledge of the distribution, amount, and physical characteristics of the recent sediments in the Bay is fundamental to understanding the behavior and fate of toxic substances in the estuary. In addition to the physical characteristics, the content of organic carbon and sulphur plays an important role in determining the redox state of the sediments after disposition. The water content correlates with the stability and ease of resuspension of the bottom and with the rate at which dissolved substances diffuse through the sediment. The mineralogy of the sediment provides information on the reactivity of the inorganic particulate constituents. These parameters together form the framework into which the chemical and biological pieces of the system fit.

The most basic data concerning sediments in the estuary are:

1. location in the system,
2. morphology of deposits,
3. physical and chemical characteristics,
4. rate of addition to the system,
5. sources, and
6. sites and rates of present accumulation.

In Chesapeake Bay, geophysical methods have been used to examine the thickness and morphology of the bottom sediment (Maryland Geological Survey, Virginia Institute of Marine Science, open file reports). These methods also provide information on some other sediment properties in that sand and shell layers can be differentiated from finer silty and muddy sediments.

The physical characteristics of the surface sediments (particle size distribution, water content) have been determined for the entire Bay; on a 1 km grid in Maryland waters and on a 1.4 km grid in Virginia waters. In addition, these same properties have been determined on a selected suite of meter length cores collected between the Susquehanna River and the Virginia capes. Sediment, on the basis of particle size, displays a relatively systematic distribution pattern with sand occurring in the shallow shoreline areas and mud in the deeper mid-Bay regions. Between, there occurs a zone of mixing of these two sediment types (Byrne 1980, Kerhin 1980). This sediment work provides a description of the state of the system relative to sediments at the present time in history and it will serve as a valuable baseline against which future changes can be measured.

Three major sources contribute sediment to Chesapeake Bay: tributary rivers, shoreline erosion and marine inflow. The northern part of the Bay is dominated by sediment carried via the Susquehanna River; the southern Bay, by sediments transported by inflowing coastal marine waters; and the mid-Bay region, by sediments derived from shoreline erosion.

Each of the tributary rivers, with exception of the Susquehanna, is characterized by an estuarine segment in its lower reaches. A large part of the sediment carried by these rivers is trapped in their lower estuarine portions and never reaches the main Bay. As a consequence, infilling of the middle portion of the Bay is occurring at a slower rate than to the north or south, with fine particle size sediment that escapes the tributary estuaries collecting in the deeper areas and coarse sediment derived from shoreline erosion accumulating in the shallow waters adjacent to the shorelines. The Susquehanna River debouches directly into the upper Bay and the bulk of the sediment it carries is deposited there. Sediments from the continental shelf, carried into the Bay in the saline bottom waters, dominate the southern segment of the Chesapeake Bay.

It is important to know what changes have occurred in the system in the past so that predictions can be made concerning future trends. In order to understand how the system has changed from past to present, and to identify impacts related to man's activities, we must rely on information recorded in the sediment. To interpret this record, we must first know the time interval represented by the record. Three independent methods for deciphering the time (rate) of sedimentation have been employed in the Chesapeake Bay: (1) comparison of historical bathymetric charts, (2) pollen biostratigraphy, and (3) Pb^{210} geochronology. Parts of the Bay have been surveyed bathymetrically at irregular time intervals beginning in 1846. Where these surveys overlap, the change in depth represents the amount of deposition (or erosion) that has occurred during the time between surveys (Maryland Geological Survey, Virginia Institute of Marine Science, open file reports). A second technique is based on pollen biostratigraphy, that is, the identification of specific time horizons in the sediment recognized by pollen distribution. For instance, the time of disappearance of American chestnut in the 1930s, in response to the chestnut blight, is recorded by the absence of chestnut pollen in sediments deposited after that time. Other identifiable horizons, both older and younger, have been recognized in Chesapeake Bay sediments and are valuable time markers in this system (Brush 1980). A third technique employs the decay of a radioactive isotope of lead. Pb^{210}, a member of the U^{238} series, is continuously being added to the earth's surface environment. It adsorbs strongly onto sediment particles and is deposited with them wherever they accumulate. Once buried beneath the sediment-water interface, no additional Pb^{210} can be added, and that contained in the sediment continues to decay at a constant rate (half life = 22.5 years). This permits the dating of sediments back to approximately 100-125 years B.P. ($5 \times$ half life) (Setlock and Helz 1980). Each of these methods provides an estimate of the rate at which sediment has accumulated at the site sampled. In areas of the Bay where sedimentation rates have been determined by either two or all three of the above techniques, the correspondence is usually quite good. Using this information, the age of a particular layer or bed of sediment can be dated by its depth beneath the surface. If a change in the concentration of any toxic substance is observed as a function of depth, the rate of loading of that substance can be inferred and projections made about future concentration trends. The time of introduction of various substances into the system can also be documented. Data about sedimentation rates are directly useful in planning dredge disposal sites, locating channels to provide minimum maintenance, and estimating the frequency and volumes of material that will have to be dredged in order to maintain harbors and channels in various parts of the system.

Toxic Substances

Along with knowledge of the distribution and physical characteristics of bottom sediments in the estuary, it is necessary to know the concentrations of the toxic substances they contain if these materials are to be effectively managed.

Two major classes of toxic materials are particularly important to the estuarine environment: metals and anthropogenic organic compounds. Metals are derived from natural weathering and erosion of the metalliferous Piedmont rocks underlying the watersheds of many of the Bay tributaries, and from man's activities. Most of the organic compounds of environmental concern are strictly the product of man's chemical ingenuity. These substances enter the system via direct discharges, in input from the tributaries, in non point source runoff, and through atmospheric pathways. The distribution of these materials in surface sediments (upper few centimeters) is a result of recent deposition and accumulation in the estuary. Dated cores provide information on how the concentrations of these materials have changed with time in the sediment. Because metal behavior is better understood and analytical methods for metals are more straightforward and less expensive than those for organic compounds, the data for metals in the estuarine environment is much more detailed than that for organic compounds. Emerging evidence over the past decade suggests, however, that synthetic organic compounds may be of greater concern than metals from the standpoint of environmental degradation of aquatic systems.

The similarity in behavior between metals and many organic pollutants with respect to sorption behavior on fine particle size sediment suggest that metals may be used as surrogates for predicting the transport and accumulation of many organic pollutants. A limited number of samples of surface sediment from the main stem of the Chesapeake Bay have been analyzed for organic compounds using glass capillary gas chromatography/mass spectrometry (GC/MS) and corroborate this hypothesis. Preliminary inspection of both the metals data and the organics data shows that the highest concentrations of these substances occur in samples from tributary mouths, suggesting that the tributaries act as sources of these materials to the main Bay (Huggett 1980). Not surprisingly, the highest concentrations were observed at the mouths of the Susquehanna, Patapsco, and James rivers.

The technical complexity and expense of analyzing estuarine samples for organic compounds led to the development of a strategy for maximizing the output of data of the type that would be most useful to identify potential problems with these compounds. Instead of trying to identify each peak (compound) on GC/MS traces, the complete GC/MS output from each sample is stored on the computer. Subsequent sampling at the same localities using the same analytical procedures discloses changes in peak height (concentration) for the organic compounds. If there has been a significant increase in any peak from one sampling period to the next, the compound represented by that peak can be identified and evaluated with respect to its toxicity and potential impact on the system. Possible sources of the compound can be identified by concentration gradients provided by a more detailed sampling grid in that particular area of the Bay, and appropriate regulatory measure instituted. The chances of associating a particular compound with its source are increased by performing identical analytical work on industrial, municipal sewage treatment plant, and power plant discharges into the Bay (Monsanto Research Corporation 1980). By periodically analyzing effluent discharges, it may be possible to stop a potential toxic problem at a very early stage before the substance has been discharged into the environment in large quantities. The frequency of sampling, however, must be appropriate to correspond to changes in process or treatment in the plants. One serious drawback is that the direct discharge analysis may not detect some toxic substances present in very small concentrations, yet if these substances are strongly sorbed by sediment or bioaccumulated by organisms, they may build up to dangerously high levels in the environment. By emphasizing the sediment and biota sampling in the estuary, and supplementing this with periodic sampling of effluent discharges, it may be possible to manage toxic substances from point sources in a much more effective manner than is presently being done. An up-to-date inventory of raw materials, processes and finished products from all dischargers into the estuary would aid greatly in assessing the loading of toxic materials in the Bay system.

Coupling the data on toxic substances in the sediment with the compositions and volumes of industrial discharges and the type of inventory data described above, it will be possible to identify those substances that accumulate in the environment and permit estimates of mass-balance budgets for specific toxic substances of concern. Combining this information with the distribution and physical characteristics of the sediment will disclose specific toxic substance-sediment associations. Extending this type of work to dated core samples will provide estimates of changes in loading of toxic substances with time.

Perhaps as important as knowledge of the identities and spatial distribution of toxic substances in the estuary is an understanding of how these substances behave in the environment. After deposition and burial in the bottom, sediments and associated toxic substances are exposed to an anoxic reducing environment. This leads to changes in speciation, desorption, dissolution and remobilization of many elements (Elderfield and Hepworth 1975). Three major mechanisms lead to the reintroduction of these materials at the sediment surface and to the water column: (1) transport in the dissolved state in the interstitial water via diffusion and/or advection, (2) physical transport of sediment and interstitial water by benthic infauna (bioturbation, irrigation, ventilation), and (3) physical disturbance of the sediment by storms and by man's activities (dredging, propeller wash, etc.). Investigation of the metal and organic content of the sediment areally and with depth provides information which permits prediction of the chemical impacts of re-exposure of sediments at the surface. Sampling and analysis of interstitial waters provides a data base from which flux of metals and nutrients into the water column can be calculated. Available data disclose that the sediment behaves as an important source of nutrients to the estuary (Maryland Geological Survey, open file reports). At certain times of the year, a significant flux of dissolved manganese and iron into the deep bottom waters is also observed. Data for other metals is not yet available. In addition to nutrient and metals flux calculations, the interstitial water chemistry provides critical information on the reactions that occur within the sediment and the composition of the aqueous environment in which the benthic infauna live.

Examination of the benthic fauna, particularly the infauna, is providing a picture of the distribution of organisms in the estuary as a function of salinity, sediment type, and depth beneath the sediment-water interface (Maryland Geological Survey, Virginia Institute of Marine Science, open file reports). These studies document the effects of the benthic communities on the disturbance and mixing of the sediment (bioturbation), the stabilization-destabilization of the bottom sediments relative to erosion and resuspension, and the role of burrows and other biogenic structures on physical and chemical processes occurring in the sediments. Benthic organisms are restricted in their mobility and therefore must adapt to any changes that occur in the local environment. For this reason, benthic organisms may be good early warning indicators of environmental degradation. Investigations in the main Bay have disclosed cycles of colonization and extermination of benthic fauna in the deep trough along the Eastern Shore, apparently in response to the yearly summer development of anoxia in the bottom waters (Reinharz and Diaz 1980). Systematic examination of benthic communities baywide, and particularly in the tributaries, may identify areas subject to environmental stress. These areas would be prime targets for detailed investigations of the causes of stress. The response of organisms—distribution, abundance, species diversity, histopathologic features, genetic effects and other biologic effects—could be used as indicators of the state of health of the particular segment of the system in which the organisms live. The foundation for developing an assessment strategy based on biologic criteria is a thorough description of the estuarine benthic organism communities in conjunction with the physical and chemical characteristics of the environment in which they live.

Present Status of Toxics in the Chesapeake Bay

The past decade has witnessed disturbing changes in the ecosystem of the Chesapeake Bay. Among the more widely publicized of these have been the decline and virtual disappearance of rooted aquatic plants from much of the Bay, the steady decrease in the abundance of striped bass and oysters, the cessation of the spring shad runs in the upper Bay, poor yields of clams and fluctuating, but generally declining catches of crabs. Individually, any one of these could be attributed to a biological cycle or some other natural phenomenon. Taken together, however, the implications are more ominous. Over the years the Bay has been under increasing pressures from a variety of man's activities. The harvesting of shellfish and finfish by commercial watermen and sport fishermen has not been effectively regulated from the standpoint of preserving the resource. An expanding population on the shores of the Bay and in the watersheds of the Bay tributaries has tremendously increased the volume of sewage effluent delivered to the estuary. Increasing need for energy has led to the siting of conventional and nuclear power plants on the shores of the Bay and along its tributary rivers. Continued industrial development in the Bay area has burdened the estuary with increased volumes of chemically complex discharges. Clearing land for agriculture and for development has greatly increased the loads of suspended sediment carried to the estuary. Chemicals in runoff from agricultural areas and in storm drainage from city streets, parking lots and highways ultimately end up in the Bay. Only recently has it been recognized that many toxic substances, including metals and organic compounds, are transported atmospherically and enter the surface environment via precipitation and by dry fallout. The sources of these pollutants are often far removed from where they impact the earth's surface. Each of these insults takes its toll on the finite assimilative capacity and resiliance of the estuarine environment. Cumulatively, they may have reached the stage at which they exceed the regenerative capacity of certain parts of the resource. In turn, this has led to the decline and/or disappearance of some of the more sensitive biota.

What can be done to halt the degradation and reverse these trends? The tendency in the past has been to look for a single cause of the problem, such as toxic substances or excess nutrients and, thus far, the search has been less than successful. The estuarine system is very complex and each of the diverse activities mentioned above has an impact on the system; some greater than others. We observe the net integrated effect of all of these factors acting in concert, and it is thus not surprising that no simple answers have been found. Only two areas of the Bay, the Elizabeth River and Baltimore Harbor, show serious environmental degradation that can be directly attributed to toxic substances (Villa and Johnson 1974, Johnson and Villa 1976, Chu-fa Tsai et al. 1979). Even in these localities it is not possible, at present, to identify the specific effects of individual toxic elements or compounds. Over most of the Bay the effects are much more subtle and no direct cause and effect relationships have yet been demonstrated.

Effective management of toxic substances in the estuarine environment requires regulation of the amount of each toxic substance delivered to the system from all sources in order to keep environmental concentrations below the level at which adverse impacts occur. This regulation must be based on a firm understanding of the behavior and fate of natural and anthropogenic toxic substances introduced into the system; the effects of these toxic substances on estuarine biota; the identification of the sources contributing toxic substances; and quantification of the load of each substance delivered by each source. At the present time, there is no comprehensive inventory of loadings to the system and there is only fragmentary information concerning the types and concentrations of toxic substances already in the environment. There is a moderate body of information relative to the behavior and fate of metals in the estuarine environment; however, similar information about toxic organic compounds is difficult or impossible to find. Perhaps the largest gap is in our understanding of the effects of toxic substances, both metals and organic compounds, on the estuarine biota.

The Environmental Protection Agency Chesapeake Bay Program represents a beginning effort to begin to address these questions; however, research of this nature must be intensified and expanded if it is to provide the data necessary to develop an effective program for the management of toxic substances in the estuarine environment. Future federal and state programs should make every attempt to build on this data and expand our understanding of toxic substances in the Chesapeake Bay system.

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The Chesapeake Bay's Birds and Organochlorine Pollutants

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Birds of the Chesapeake Bay have been exposed to a variety of organochlorine pollutants. These chemicals include synthetic organochlorine insecticides that were first introduced in the mid-1940s and polychlorinated biphenyls (PCBs), a group of synthetic chlorinated hydrocarbons that have been widely used as industrial chemicals for about 50 years. Organochlorines affect birds directly and indirectly; some chemicals are highly toxic and can cause mortality directly, whereas others reduce reproductive success or cause subtle effects on the ecosystem (see Ketchum et al. 1975, Stickel 1975, White and Stickel 1975, Stendell 1976, Blus et al. 1977, Ohlendorf et al. 1978c for general reviews).

Organochlorine pesticides, PCBs, and certain other persistent toxic chemicals are widely dispersed in the environment and are commonly found in tissues and eggs of wild birds from the Arctic to the Antarctic. The most common organochlorine pollutant found in wild birds is usually DDE, a metabolite of DDT. Other DDT compounds frequently present in birds include DDD (also called TDE) and DDT itself. PCBs are usually the second-most-common organochlorine pollutant found in wild birds. Dieldrin, which was applied as an insecticide and is also a metabolite of aldrin (another insecticide), is frequently found in birds. A number of other synthetic organochlorine compounds have been detected in birds from the Chesapeake Bay, but usually at levels lower than those of DDE, PCBs, and dieldrin; they are therefore of less concern. Some of these chemicals include heptachlor epoxide, toxaphene, mirex, Kepone, and various chlordane compounds.

Organochlorine concentrations in carcasses of birds are considered the best measure of sublethal exposure, whereas concentrations in brains are best to use for diagnosing death by organochlorine poisoning (see Heinz et al. 1979 and Ohlendorf et al. 1979b for review). Residue concentrations in eggs serve as an index to the concentrations in the female at the time the egg was laid, and concentrations in wings also are correlated with those in the carcasses (Dindal and Peterle 1968, Clark and McLane 1974, Ohlendorf et al. 1978c).

Organochlorines are stored in fat and may be carried in large amounts after heavy but sublethal exposure. Depletion of fat can result in residue mobilization, redistribution, and increased residues in some other tissues (see Stickel 1975, Ohlendorf et al. 1978c, Wiemeyer et al. 1980 for discussion). Death may occur when organochlorines are redistributed to the brain and reach lethal concentrations there.

Field and experimental evidence indicates that declines in eggshell thickness observed in certain species in North America and Great Britain since the mid-1940s have been largely caused by DDE (Cooke 1973). At moderate or high levels of DDE, shell thinning is severe; eggs may crack or break during incubation, resulting in reproductive failure for the birds.

In this paper I shall focus on the aquatic species of the Bay itself, but I also include some information on estuarine species from nearby coastal areas and terrestrial species of the Bay's watershed. All residue concentrations in this paper are expressed on a wet-weight basis.

Conditions in the Past

Some birds of the Chesapeake Bay region, and especially those at higher trophic levels in the food chain, have been adversely affected by organochlorines; eggshell thinning has occurred in several species that inhabit the Bay area.

Raptors

Bald eagle (*Haliaeetus leucocephalus*) populations declined in the Chesapeake Bay and other areas of the United States between 1950 and 1975; most populations have now stabilized, and some are increasing (Broley 1958, Sprunt and Ligas 1966, Abbott 1967, S. N. Wiemeyer, pers. comm.). Bald eagles found dead or moribund throughout the United States are autopsied to determine, when possible, the cause of death. Tissues are then analyzed for organochlorine pesticides and PCBs. Causes of bald eagle mortality were first summarized for 1960-65 (Coon et al. 1970), and other reports of autopsy and residue findings have been published periodically (Reichel et al. 1969a, 1969b, Mulhern et al. 1970, Belisle et al. 1972, Cromartie et al. 1975, Prouty et al. 1977, Kaiser et al. 1980). More than 440 eagles, including 22 from Maryland and Virginia, have thus far been analyzed. DDE and PCBs have been found in almost every eagle; this was also true of DDD and dieldrin until about 1974, when frequency of occurrence of these two organochlorines decreased somewhat. DDT, heptachlor epoxide, mirex, and various other organochlorines were commonly but less frequently detected. Overall, DDE, dieldrin, and PCB concentrations appear to be declining in bald eagles. Although shooting is consistently the leading cause of death, about 5 percent of the bald eagles have hazardous or lethal concentrations of dieldrin in their brains; the frequency of apparent dieldrin-caused mortality was higher in the earlier years. Several of the eagles with high concentrations of dieldrin have come from the Chesapeake Bay tidewater area.

Bald eagles collected from the Maryland-Virginia Chesapeake Bay tidewater area in 1968-75 had Kepone in their livers and carcass tissues (Stafford et al. 1978). An eagle from Warsaw, Virginia, about 30 miles from the James River, contained the highest concentration of Kepone (130 ppm) in the liver. In samples collected in 1976, Kepone concentrations ranged from 0.14 to 0.19 ppm in three eagle eggs from the Potomac River and 0.05 to 1.5 ppm in 17 osprey (*Pandion haliaetus*) eggs from the Rappahannock and York rivers. The biological significance of these residues is not known.

Organocholorine levels in bald eagle eggs from the Chesapeake Bay area in the 1970s were among the highest for populations in the United States that were sampled (S. N. Wiemeyer, pers. comm.), and eggs from nonproductive eagle nests in Maine contained much higher organochlorine concentrations than did eggs collected from either productive or nonproductive nests in Wisconsin and Florida (Krantz et al. 1970). Significant eggshell thinning has occurred in bald eagles from most major areas sampled, including the Chesapeake Bay (Hickey and Anderson 1968, Anderson and Hickey 1972, Wiemeyer et al. 1972, S. N.Wiemeyer, pers. comm). Some eggs contained DDE residues of the same magnitude as those that produce shell thinning in experimental American kestrels (*Falco sparverius*) fed a low dietary level of DDE (Wiemeyer and Porter 1970).

The Chesapeake Bay area has a large population of ospreys (Wiemeyer 1971, Henny et al. 1974, Kennedy 1977, Reese 1977). Some populations of ospreys in North America, especially those in some northeastern states, declined in the 1950s and 1960s to only a remnant of their previous levels (Henny 1977).

Ospreys nesting along the Potomac River appeared to reproduce at a near-normal rate in the 1960s, but reproductive success during the early 1970s fell to about one-half to two-thirds of the success needed to maintain the population (Wiemeyer 1971, 1977, Blus et al. 1977, Kennedy 1977). Egg failure was the major cause of poor success in this area as well as in central Chesapeake Bay in the early 1970s (Reese 1977). Furthermore, it appeared that even less successful reproduction by ospreys in Connecticut was also related to contamination of the birds and their eggs (Wiemeyer et al. 1975). Eggs were exchanged between active nests in the two nesting areas in 1968 and 1969; hatching success of the transplanted eggs was similar to that in the region where they were laid. Concentrations of DDE (8.9 ppm versus 2.4 ppm), dieldrin (0.61 ppm; 0.25 ppm), and PCBs (15 ppm; 2.6 ppm) in eggs from Connecticut were much higher than in eggs from Maryland. When the average residue content for eggs from a nest equalled or exceeded 12 ppm DDE, 1 ppm dieldrin, or 15 ppm PCBs, no eggs from that nest were known to hatch during that year. Osprey eggshells from Maryland were 10 percent thinner than normal; those from Connecticut 18 percent thinner. Anderson and Hickey (1972) reported an 18 percent decline in eggshell weight for a small sample of osprey eggs collected in New Jersey, Maryland, and Connecticut in 1957.

The osprey was among the first species of fish-eating and raptorial birds in North America to show a pattern of eggshell thinning in local populations (Hickey and Anderson 1968, Anderson and Hickey 1972). Other reports of eggshell thinning in ospreys have subsequently been published (see Reese 1977). Eggshell thickness was negatively correlated with DDE, PCBs, and mercury; the best correlation was with DDE (Spitzer et al. 1977).

Ospreys that were found dead or moribund in the eastern United States between 1964 and 1973, many of which were from the Chesapeake Bay area, commonly had DDE, PCBs, DDD, dieldrin, DDT, heptachlor epoxide, and chlordanes (including nonachlors) in their bodies (Wiemeyer et al. 1975, 1980). Most adults from this area were obtained in April and May, whereas most immatures were found in August through October.

Eggs of barn owls (*Tyto alba*) were collected from 18 nests in offshore duck blinds on the Maryland side of the lower Potomac River estuary in 1972 and 1973 and were analyzed for organochlorines (Klaas et al. 1978). DDE was found in all of the clutches, PCBs in 89 percent, and dieldrin in 78 percent. Eggshell thickness was inversely correlated with concentrations of DDE, DDD, and dieldrin. Six of the 18 clutches had mean DDE residues above 5 ppm, and eggshell thickness in these six clutches was significantly less than in the other 12 clutches. The owls produced 1.7 young per active nest in 1973. This rate is slightly below the reproductive rate needed to maintain a stable population. An estimated 15 percent of the population carried concentrations of organochlorines that may have been detrimental to their reproduction. Passerine birds, taken extensively as food by a small proportion of the population, are believed to have been the source of elevated concentrations of organochlorines in these barn owls.

Waterfowl

Chesapeake Bay is a principal wintering area for canvasbacks (*Aythya valisineria*) (Bellrose 1976). In 1972, biologists at the Patuxent Wildlife Research Center began studying canvasbacks collected from the Bay to determine levels of various environmental pollutants in tissues and food items. Canvasback blood in 1972-74 (Dieter et al. 1976) and carcasses in 1973, 1975, and 1976 (White et al. 1979) generally contained low concentrations of organochlorine pesticides and PCBs. Experimental studies with other waterfowl species suggest that these residues are below levels known to have an adverse effect on avian reproduction and survival. A few samples, however, did contain amounts of DDE or PCBs at about the concentrations where adverse effects may be expected.

Black duck (*Anas rubripes*) eggs were collected in 1964, 1971, and 1978 to assess possible effects of environmental pollutants on reproduction (Reichel and Addy 1968, Longcore and Mulhern 1973, Haseltine et al. 1980). These studies were conducted because of concern about the apparent decline in black duck populations in the Atlantic Flyway (Kaczynski and Chamberlain 1968, Martinson et al. 1968). In the 1964 study, DDE averaged over 4 ppm in eggs from three states and DDT was present in all eggs analyzed. By 1971, DDT had decreased and there was a downward trend in DDE concentrations, but individual eggs still contained DDE levels comparable to those in 1964. Black duck eggs were again collected in 1978, when one egg from each of 49 clutches was analyzed for organochlorine compounds and mercury. DDE was present in 39 eggs, ranging from 0.09 ppm to 3.4 ppm. Average DDE concentrations were highest (2.0 ppm) in eggs from Delaware. Mean DDE concentration for Maryland eggs was 0.10 ppm; it was not detected in those from Virginia. DDT and DDD were present at low concentrations in only a few eggs, but more commonly in those from Delaware than elsewhere. PCBs were generally lower in frequency and concentration than in 1971; the eggshells from Maryland and Virginia contained no detectable PCBs. In 1964 the eggs were 7.5 percent thinner and in 1971, 1.2 percent thinner than normal. Eggshell thickness in 1978 was identical to the pre-1947 norm.

The decrease in black duck eggshell thickness in 1964 (Longcore and Mulhern 1973) was probably associated with the higher DDE residues found in the black duck eggs during the 1964 survey. In experimental studies, DDE has been shown to cause shell thinning, cracked eggs, changes in mineral composition of eggshells, and lowered reproductive success in mallards (*Anas platyrhynchos*) and black ducks (Heath et al. 1969, Longcore et al. 1971a, 1971b, Longcore and Samson 1973). Eggs incubated by the hens broke and cracked more frequently than those in the incubators. After DDE was removed from the diet, DDE residues in the eggs decreased, shell thickness increased, and reproductive success improved (Longcore and Stendell 1977). However, even after two years on untreated feed hens laid eggs with shells about 10 percent thinner than control hens and produced significantly fewer surviving ducklings than did control hens.

Duck wings from the contiguous 48 states are available for monitoring purposes as a byproduct of a nationwide survey of waterfowl productivity. Cooperative hunters mail thousands of wings to central collection points for biological examination (Dustman et al. 1971). Of the many species whose wings are available, those of the mallard and black duck are being analyzed in the National Pesticide Monitoring Program, because the combined ranges of these two species cover the contiguous United States. Both species occur in the Chesapeake Bay area. Waterfowl are highly mobile species and may cover a wide range of habitats in many states. Thus, the data are better interpreted on a regional or flyway basis, rather than strictly for a statewide or local geographic area.

Mallard and black duck wings have been collected periodically for monitoring purposes since 1965-66 (Heath 1969, Heath and Hill 1974, White and Heath 1976, White 1979b). DDE was the predominant residue in the early samples, followed in order by DDT, DDD, dieldrin, and heptachlor epoxide. Residues generally were highest in the Atlantic and Pacific Flyways, and lowest in the Central Flyway. In 1969-70 there was no indication of a decrease in levels from 1965-66. Duck wings were first analyzed for PCBs in the 1969-70 samples, and PCBs were found to be second only to DDE in overall prevalence. In 1972-73, both mallards and black ducks from the Atlantic Flyway contained significantly lower DDE concentrations than in 1969-70. Black ducks also contained significantly less dieldrin than in 1969-70, but there was no change in PCBs in either species. DDE was found in all samples collected in 1976-77, as it had been previously in each but the first collection. DDE and dieldrin levels were unchanged in the Atlantic Flyway from 1972 to 1976. Different quantitation methods were used for PCBs in the two years, so the results are not comparable. However, PCBs were detected in all samples of both species in both years. Frequency of DDT and DDD decreased from 100 percent in 1972 to 50-69 percent and dieldrin from 100 percent to 84 or 85 percent in mallards and black ducks from the Atlantic Flyway.

Wading Birds

In 1972 and 1973, we collected eggs of wading birds (herons, ibises, and related species) at 50 sites throughout the eastern United States to determine (1) geographic differences in the occurrence of organochlorine pollutants in these species, (2) differences in organochlorine concentrations among those species nesting at the same sites, and (3) whether eggshell thickness had changed since the widespread use of organochlorine insecticides began in the mid-1940s (Ohlendorf et al. 1978a, 1978b, 1979a). Several collecting sites were in the Chesapeake Bay area, and organochlorine concentrations in eggs from those colonies probably reflect the general pattern of contamination in the region. Samples were collected on the Potomac River, in Chincoteague Bay, and in coastal areas of New Jersey.

Organochlorine concentrations were usually higher in eggs from the Northern Atlantic Coast (New York to Massachusetts) and Great Lakes regions than elsewhere. Among species, highest organochlorine concentrations were usually in eggs of great blue herons (*Ardea herodias*), wood storks (*Mycteria americana*), black-crowned night herons (*Nycticorax nycticorax*), and great egrets (*Casmerodius albus*).

We did not detect eggshell thinning in any species from the Bay area. Shell thickness for black-crowned night heron eggs from New Jersey and other colonies farther north along the coast was significantly thinner than the pre-1947 norm. This corresponded with higher organochlorine concentrations in the more northern colonies.

Since 1966, 72 herons found dead or moribund in the field have been analyzed for organochlorines (Ohlendorf et al. 1979b, 1981). Twenty-seven of these birds were from the Chesapeake Bay area. Carcasses were analyzed to determine sublethal exposure to organochlorines; brains of selected birds were analyzed to determine whether the birds had died of organochlorine poisoning. Organochlorine concentrations were almost always higher in adult herons than in immatures. More than 20 percent of the herons from throughout the nation had hazardous or lethal concentrations of organochlorines in their brains—all were adults, and most were great blue herons. Of the birds from the Chesapeake Bay area, three great blue herons from Virginia (found in 1970, 1972, and 1974) had levels of dieldrin that may have been lethal. However, they also had verminous peritonitis caused by nematodes (*Eustrongylides* sp.) that probably contributed to their deaths. Two cattle egrets (*Bubulcus ibis*) that were found dead in fields of Maryland's Eastern Shore in 1978 probably died of dieldrin poisoning. Dieldrin was banned for most uses in the United States in 1975 (Anonymous 1977). We do not know whether the cattle egrets were exposed locally or elsewhere.

Other Species

Herring gull (*Larus argentatus*) eggs from Fisherman Island, Virginia, in 1977 contained relatively low concentrations of several organochlorines (Szaro et al. 1979). Kepone was not detected in the six eggs that were analyzed for this compound, but DDE (mean concentration of 1.93 ppm) and PCBs (9.06 ppm) were detected in each of 28 eggs. The eggshells, however, were of normal thickness.

Starlings (*Sturnus vulgaris*) collected in the National Pesticide Monitoring Program showed decreasing concentrations of organochlorines from 1967 through 1974, but there was an apparent increase in 1976 (Martin 1969, Martin and Nickerson 1972, Nickerson and Barbehenn 1975, White 1976, 1979a). Nationwide, residues of DDE in starlings increased significantly from 1974 to 1976 to about the level reported in 1970, before the use of DDT was suspended (Anonymous 1977). Dieldrin declined steadily between 1970 and 1974, but the average dieldrin concentration in 1976 was about the same as the 1974 average, indicating no further decline during that 2-year period. PCBs were detected in only 26 of 126 samples in 1976, whereas they were found in all samples previously. Starling samples collected from Virginia in several years reflected the same pattern of organochlorine occurrence as the nationwide average, except that those from Caroline County showed a continued decline of DDE concentrations in recent years.

Woodcock (*Philohela minor*) wings have periodically been monitored for organochlorine pesticides and PCBs in the eastern United States since 1971 (McLane et al. 1973, 1978, Clark and McLane 1974, M. A. R. McLane and D. L. Hughes, unpublished manuscript). There were regional differences in concentrations of several agricultural insecticides and PCBs in the woodcock; DDE and PCB concentrations have generally declined during the period of study.

Woodcock from Maryland were included in the sampling in 1970-71 (Clark and McLane 1974) and in 1975 (M. A. R. McLane and D. L. Hughes, unpublished manuscript), but the data do not clearly reveal trends that might reflect Chesapeake Bay watershed conditions. Sample distribution from Maryland in these two surveys was different; the 1970-71 samples included breast muscles from five birds of mixed ages from four counties, whereas the 1975 samples were five statewide pools of wings from 25 adult birds each. Thus, the apparent increase in average organochlorine residue content for some chemicals (particularly DDT and its metabolites) in birds from Maryland is not readily interpreted.

Woodcock eggs and eggshells were collected from 10 states, including Maryland and Virginia, in 1971 for comparison of shell thickness with normal eggs collected before 1940 (Kreitzer 1973). Hatched woodcock eggs or those containing fully developed embryos were about 10 percent thinner than both unembryonated shells from the same year and those collected before 1940. The difference was attributed to the transfer of calcium from the shells to the embryos and not to organochlorine pollutants.

American oystercatcher (*Haematopus ostralegus*) eggs from Texas and the southern Atlantic coast of the United States in 1955-69 showed a statistically significant but minor decrease (4.7 percent) in eggshell thickness from normal pre-1947 eggs (Morrison and Kiff 1979).

Mourning dove (*Zenaida macroura*) breast muscle samples were taken from birds collected in 1970-71 from 15 eastern states, including Maryland and Virginia (Kreitzer 1974). DDE and PCB concentrations in doves from the Chesapeake Bay area were low. Likewise, thickness of eggshells collected in 1969 and 1970 was not different than the pre-1947 norm (Kreitzer 1971). Organochlorine pollutants probably were not responsible for the decline of mourning dove populations in the United States during 1960-70.

Recent Trends

Organochlorine compounds are still present in birds of the Chesapeake Bay. However, DDT and dieldrin, the two organochlorine insecticides of primary concern, have been cancelled for most uses in the United States (Anonymous 1977). Use of most other organochlorine insecticides also has declined in recent years. Production of Kepone in Hopewell, Virginia, resulted in contamination of the James River, but the manufacturing plant has now been closed (Huff and Gerstner 1978). Although PCBs are found in a wide range of environmental samples, sales of PCBs have been curtailed by the manufacturer since 1971 (Nisbet 1976). Thus, there has been somewhat less concern recently about the effects of organochlorine pollutants than about other environmental contaminants affecting wildlife. Newer types of pesticides and other agricultural chemicals as well as industrial and energy-related contaminants have been of primary concern.

Several studies mentioned in the previous section have shown that concentrations of DDT and its metabolites in wild birds of the Atlantic coast are declining. A few other examples of such information further reflect recent trends in organochlorine pollutants in the environment.

Brown pelican (*Pelecanus occidentalis*) populations in the southeastern United States declined severely during the 1960s, and organochlorine pesticides were implicated as a cause for the decline. This led to an extensive study of the effects of organochlorine residues on eggshell thickness, reproduction, and population status of brown pelicans in South Carolina and Florida (Blus et al. 1971, 1972, 1974, 1979a, Mendenhall and Prouty 1978). Other species also were studied in some detail in South Carolina (Blus and Lamont 1979, Blus and Prouty 1979, Blus et al. 1979b). Organochlorines caused eggshell thinning and reduced reproductive success of brown pelicans in the more contaminated areas. Between 1969 and 1977, DDE and dieldrin concentrations in the eggs declined gradually, reproductive success improved, and the breeding population doubled. DDE residues have also declined in the principal food fish. PCB concentrations in pelican eggs have fluctuated with no obvious trend. The same trends in residue concentrations occurred in several other estuarine birds in South Carolina.

In our 1972-73 study of organochlorines in wading birds, we were especially concerned about the black-crowned night heron because of population declines that had been reported in New England and in Michigan (see Ohlendorf et al. 1978a for review). We could not positively relate the organochlorine residues we found in eggs to the declines of night heron populations, but circumstantial evidence suggests that these pollutants may have contributed to impaired reproduction in the more contaminated areas, which coincided with the areas of population decline. In 1979, organochlorine concentrations in night heron eggs had declined in Massachusetts and Rhode Island colonies, eggshell thickness was back to normal, and reproductive success was good (Custer et al. 1980; T. W. Custer, pers. comm.).

DDT was used extensively to control mosquitoes in salt marsh estuaries of Cape May County, New Jersey from 1946 to 1966 (Klaas and Belisle 1977). In 1967, mean concentrations of DDT and metabolites ranged from 0.63 to 9.05 ppm in aquatic fauna, but by 1973 mean residue concentrations had decreased 84 to 99 percent among nine species. DDE was still present at reduced levels in nearly all samples in 1973, but other DDT isomers had mostly disappeared. Dieldrin also declined during the period; PCBs varied among species, declining in some and increasing in others.

Juvenile estuarine fish were collected nationwide from 1972 through 1976 and mollusks were sampled in 1965-72 (Butler 1973, Butler and Schutzmann 1978). Both of these studies revealed widespread contamination of estuaries but that residue concentrations were declining.

Future Outlook

There are still areas of particular concern about organochlorine contamination of the environment, and it is necessary to continue monitoring susceptible bird populations in relation to those pollutants. However, in general it appears that the impact of these chemicals in the future should be much less than it has been in the past 35 years. In the Chesapeake Bay attention should be focused on fish-eating birds, primarily bald eagles and ospreys, but it is unlikely that organochlorines will represent a serious threat to these species, or others of the Chesapeake Bay region.

Acknowledgements

I thank Susan D. Haseltine and Stanley N. Wiemeyer for their helpful review of the manuscript.

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Submerged Aquatic Vegetation of the Chesapeake Bay: Past, Present and Future

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Introduction

The intertidal and nearshore subtidal regions of estuaries, bays, and rivers represent extremely important areas in coastal zone productivity. Their importance lies in the fact that these shallow zones can be colonized by vast expanses of wetlands and submerged aquatic vegetation (SAV).

SAV systems serve multiple, functional roles in coastal ecosystems (Wood et al. 1969, Thayer et al. 1975, Stevenson and Confer 1978). They superimpose a structural component on an otherwise bare sand or mud bottom. This structure serves as a habitat for many small sessile and slow moving invertebrate species. The density and diversity of invertebrate species found in the sediments surrounding the leaves are significantly higher than adjacent, unvegetated areas (Marsh 1973, 1976, Orth 1977). There is also a much higher density of the more motile, macroinvertebrate species such as shrimp and crabs in vegetated areas compared with unvegetated areas (Heck and Orth 1980a). SAV areas function as refuges for these same motile species by providing a source of protection from predators. The effectiveness of this refuge is apparently directly related to the density of vegetation (Heck and Orth 1980b). The blades of SAV support a diverse and sometimes very dense epiphytic growth which is a source of food for herbivores and thus contributes to the overall high productivity of the system.

Within the Chesapeake Bay, there are extensive littoral areas that are heavily vegetated with submerged aquatic vegetation. The Bay with its salinity regime spanning a range of 0 to 25‰ is represented by a variety of different SAV community types (Anderson 1972, Stevenson and Confer 1978). The polyhaline and mesohaline areas are dominated by eelgrass (*Zostera marina*) and wigdeon grass (*Ruppia maritima*) while in the oligohaline and fresh water regions, there are approximately 20 species of SAV which include redhead grass (*Potamogeton perfoliatus*), sago pondweed (*Potamogeton pectinatus*), wild celery (*Vallisneria americana*), and horned pondweed (*Zannichellia palustris*). Historically, emphasis on Chesapeake Bay SAV has been directed to its importance as a food for waterfowl. However, with the decline of SAV throughout the Bay in the early 1970s (Stevenson and Confer 1978), the importance of SAV for primary production, nutrient cycling, prey refuge, contribution to food webs, and sediment dynamics is now becoming apparent. It may be that the SAV systems constitute one of the most scientifically as well as aesthetically interesting areas in the Bay.

In the last three years, submerged aquatic vegetation (SAV) has been the subject of an intensive research program funded by the U.S. Environmental Protection Agency's Chesapeake Bay Program (CBP). The CBP identified the area of SAV as a high priority area of research because of its important role in the Chesapeake

Contribution No. 987 from the Virginia Institute of Marine Science of the College of William and Mary.

Bay ecosystem and the fact that there had been a dramatic decline in distribution and abundance of SAV in the early 1970s.

One of the main elements of the SAV program was to examine the current distribution and abundance of submerged grasses in the Chesapeake Bay and to compare this to the historical record for significant alterations in the distribution and abundance of SAV.

The intent of this paper will be to examine the present status of SAV in the Bay, identify past trends and attempt to forecast the future using what we now know about SAV systems.

Methods

The accurate delineation of communities of submerged aquatic vegetation for the purpose of analyzing their distribution and abundance can be exceedingly difficult, if not impossible, especially when the areas of interest may incorporate hundreds of miles of shoreline. In addition, these communities are not static but represent dynamic elements whose distribution and abundance can vary in both space and time. Distinct differences in SAV beds can be observed in time frames of less than six months. In order to avoid the problems associated with labor intensive and cost ineffective field surveys, remote sensing techniques (aerial photography) were used to acquire a synoptic view of SAV beds.

In 1978, the entire shoreline of the Chesapeake Bay and its tributaries from the Susquehanna Flats to the mouth of the Bay were flown with light planes equipped with mapping cameras in order to acquire aerial photographs of all existing beds of SAV (See Orth et al. 1979, and Anderson and Macomber 1980, for detailed information on methodologies used for this work). The imagery of the grass beds was then mapped onto standard U.S. Geological Survey topographic quadrangles (1:24000) and areas of the grass beds calculated with an electronic planimeter.

In order to corroborate the information on the aerial photographs, ground truth information was acquired by conducting field surveys to selected sites with a small boat or float plane. This also allowed more detailed examination of species type as well as spatial distribution of each species within selected areas.

Data for the past distribution and abundance of SAV in the Bay were acquired from two sources. Historical aerial photographs dating back to 1937 were available through the U.S. Geological Survey, U.S. Department of Agriculture–Soil Conservation Service, National Oceanic and Atmospheric Administration and the Department of Highways. Despite the fact that these photographs were taken for other purposes, many provided adequate information in order to delineate beds of SAV. In addition to the photographs, historical information on species presence and their relative abundance was available from numerous field surveys conducted by the Migratory Bird and Habitat Research Laboratory, and the Maryland Department of Natural Resources, as well as individual scientists throughout the Bay area.

For discussion in this paper, the Bay has been divided into three zones (Figure 1). The zone between the mouth of the Bay and to a line stretching from the mouth of the Potomac River to just above Smith Island will be referred to as the lower Bay section. The zone between Smith Island and the Eastern Neck area will be referred to the middle Bay section. The zone from Eastern Neck to the Susquehanna Flats will be referred to as the upper Bay section. These zones have distinct

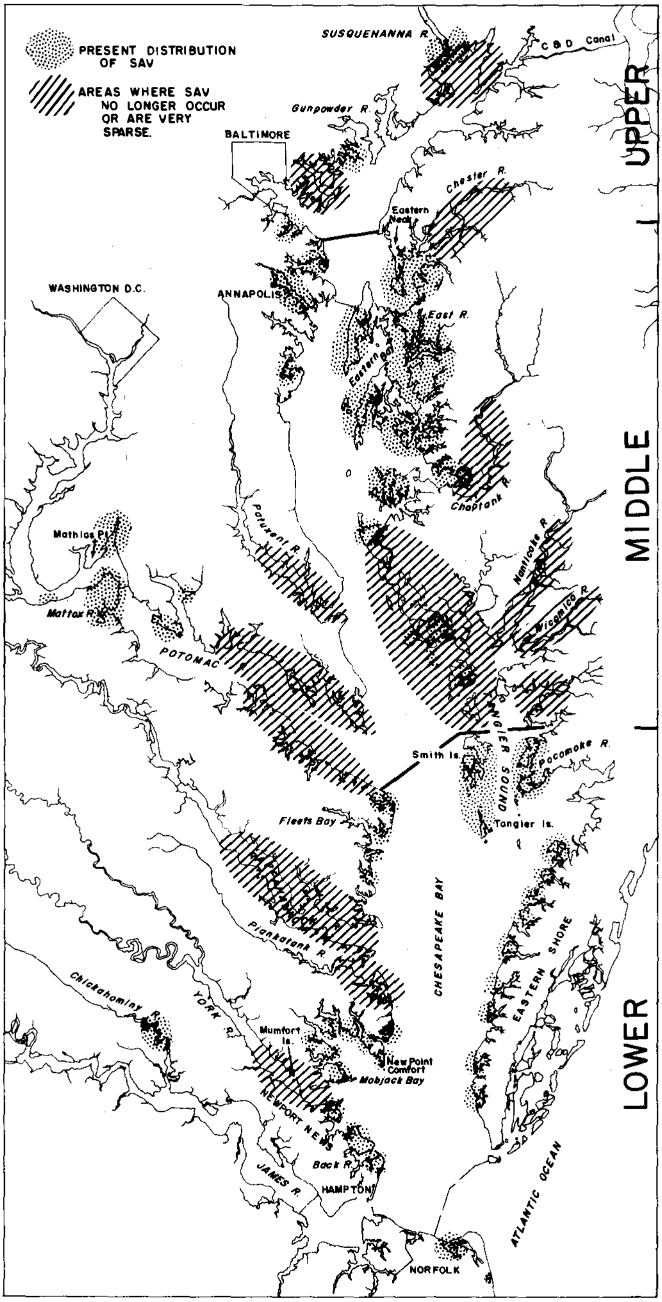


Figure 1. Map of the Chesapeake Bay showing: (1) The present distribution of SAV communities and (2) major areas where SAV communities were once very abundant in the late 1960s and early 1970s but are now absent or present only in sparse patches.

salinity regimes that will influence the type of SAV community that will grow within each area. In addition to the Bay proper, each of the Bay's major tributaries will be discussed within the zone where it connects to the Bay.

Discussion

The Species

The Chesapeake Bay, and its tributaries, support a wide variety of species of submerged grasses primarily because of the broad range of salinities found within its boundaries (0–25‰). There are approximately ten species of vascular plants that are abundant in the Bay. Approximately another ten species are found occasionally. Most of the species are found to occur in beds mixed with other species that have similar environmental tolerances. Of all environmental factors, salinity appears most important in controlling the species composition of an individual SAV bed.

Three associations of SAV can be defined based on their salinity tolerances. The first group, *Najas quadalupensis* (bushy pondweed), *Ceratophyllum demersum* (coontail) and *Elodea canadenis* (waterweed), are those species that can tolerate fresh water to slightly brackish water and are found in the upper reaches of the Bay and the tidal fresh water areas of its tributaries. The second group, *Vallisneria americana* (wild celery), *Myriophyllum spicatum* (Eurasian milfoil), *Potomogeton pectanatus* (sago pondweed), *P. perfoliatus* (redhead grass) and *Zannichelia palustris* (horned pondweed), are tolerant of slightly higher salinities and are found in the middle reaches of the Bay and its tributaries. The third group, *Zostera marina* (eelgrass) and *Ruppia maritima* (widgeon grass), are tolerant of the highest salinities found in the lower sections of the Bay. Because of the increased physiological stress of high salinity water, few species are adapted to these conditions. *Ruppia,* however, can also tolerate much lower salinities than *Zostera* and is often found associated with the second group. *Zostera* and *Ruppia* co-occur in most areas in the lower Bay with *Ruppia* dominating in the shallow sections of the bed, *Zostera* dominating the deeper areas and the two species found together at intermediate depths. It is interesting to note that despite *Ruppia's* ability to tolerate low salinities, it is rarely found in Virginia's lower salinity portions of its tributaries (Orth et al. 1979).

Present Distribution

The results of the 1978 SAV aerial survey and mapping of the entire Bay and its tributaries indicate that the Bay still contains significant stands of vegetation. However, there are major areas along the Bay and in its tributaries which historically contained submerged vegetation that are now devoid of vegetation.

In the lower Bay zone where salinities range from 12–13‰ to 25‰, two species predominate: *Zostera marina* and *Ruppia maritima,* with *Zannichelia palustris* present but occurring infrequently. At present, there are approximately 20,750 acres (8,400 hectares) of bottom covered with SAV in this zone. These grass beds range from very dense to sparse. The dominant and most dense grass flats are concentrated in several main regions of the lower Bay (Figure 1): (1) along the western shore of the Bay between Back River and York River and immediately above New Point Comfort; (2) the shoreline within the Mobjack Bay and its tributaries; (3) behind the protective sandbars along the Bay's Eastern Shore; and (4) shoal areas between Tangier Island and Smith Island.

The tributaries in this zone have no extensive fresh water or low salinity grass beds. Those that are present are usually quite small in area and are confined to tidal marsh creeks either scattered along the shoreline or in pockets at the headwaters of the tidal creeks.

There are distinct sections of the shoreline now devoid of any vegetation or with only small patches of vegetation that once contained dense stands. The lower reaches of the York, Rappahannock and Piankatank Rivers are most notable because of the almost complete loss of *Zostera* and *Ruppia* throughout these previously vegetated areas. The York River does contain scattered patches of *Zostera* up to Gloucester Point, but above this, *Zostera* is completely absent. In addition to these major tributaries, the western shore of the Bay between the Rappahannock and Potomac Rivers now only contains scattered patches of grass where formerly it contained dense stands.

In the middle zone of the Bay, SAV shift from *Zostera-Ruppia* dominated communities to the brackish water *Potomogeton, Zannichelia, Vallisneria, Myriophyllum* communities. This zone contains 17,549 acres (7,105 hectares) of bottom covered with SAV. The greatest concentration of vegetation (71 percent of the total vegetation for this section) is between the Little Choptank River and the Chester River including the Eastern Neck Area. Sixteen percent of the vegetation occurs between the Little Choptank River and Smith Island. The remainder, 13 percent, occurs along the western shore and its tributaries from the Maryland-Virginia border to just above the Magothy River. Little vegetation is found along the western shore in the region of Annapolis. The Patuxent River has virtually no vegetation, but a small amount (7.5 percent) of the total vegetation in this zone is found in the Potomac River in the vicinity of Nanjemoy Creek, Port Tobacco River, Mathais Point Neck, Mattox and Machodoc Creek.

The upper zone of the Bay from Eastern Neck and the Magothy River to the Susquehanna Flats currently contains relatively little vegetation. There are approximately 1,200 acres (484 hectares) of bottom covered with SAV with many of the same species found here as in the middle zone of the Bay but also with increased abundance of *Nais, Elodea* and *Ceratophyllum*. The Susquehanna Flats has 272 acres (110 hectares) of vegetation occurring in scattered beds. This is a tremendous reduction when compared to abundance of SAV in the late 1960s and early 1970s. Only two species are present: *Myriophyllum* and *Vallisneria* (compared with eleven species found by researchers in 1971).

The present situation of SAV in the Bay indicates the presence of many healthy beds in the lower and middle sections of the Bay. However, there are large sections of the major tributaries, e.g. the York, Rappahannock, Potomac and Piankatank Rivers, as well as main sections of the Bay, e.g. Susquehanna Flats and an area between Smith Island and Eastern Bay, that are devoid of almost all vegetation where once luxuriant beds persisted.

The Past

A detailed discussion on past trends of SAV distribution and abundance is hindered by the lack of adequate data for many sites over a long period of time.

The results of our present surveys indicate there is a distinct reduction in SAV in many areas of the Bay that transcends the species line. Species in the high salinity areas have declined as well as those in the less saline reaches of the upper Bay. Are the reductions we have observed recently similar to previous documented declines and if so, do those patterns suggest what are causal agents for the decline? If not, then what can we possibly learn from past trends that could help us in possibly interpreting present trends?

A review of the historical information indicates that SAV has in the past been very abundant throughout the Bay. However, in the last 50 years, there have been distinct periods where SAV in the Bay has undergone major fluctuations.

The most historic decline of a species in the Bay was that of eelgrass in the early 1930s. This not only affected the Bay area, but the entire East Coast of the U.S. and the west coast of Europe (Hartog 1970, Rasmussen 1977). The extent of the decline in the Bay was never quantified, but the earliest available aerial photographs from 1937 reveal patchy to medium dense areas in many sections of the lower Bay with one area on the Bay side of the Eastern Shore having very luxuriant beds in 1937, only 4 to 6 years after the height of the eelgrass decline. Subsequent aerial photographs from 1937 to 1972 reveal general increases in grass density, but with some localized decreases. Although not located within the Chesapeake Bay, the area that has never recovered from the 1930s decline includes the shallow lagoons located behind the barrier islands of Virginia's Eastern Shore. This decline has had a dramatic and lasting effect on the scallop fishery beginning during that period (Orth 1978). There is little evidence as yet to suggest that there was a loss of low salinity and freshwater species similar to that documented for eelgrass.

A second major period of extensive SAV fluctuations in the Bay was the milfoil outbreak in the late 1950s and early 1960s (Bayley et al. 1978, Stevenson and Confer 1978). Milfoil increased baywide from 49,900 acres (20,200 ha) in 1960 to 100,000 acres (40,500 ha) in 1961 (the 1978 Baywide SAV survey indicated approximately 39,500 acres (16,000 ha) for all SAV species). In creeks along the Potomac River it reached densities so high that it was considered a nuisance and attempts to eradicate it with applications of 2,4-D were initiated (Rawls 1978). The Susquehanna Flats typified these changes. In 1957, one survey found that milfoil did not occur in any sampling stations. Subsequently, it was found in 1 percent of these stations in 1958, 47 percent in 1959, 82 percent in 1960 and 89 percent in 1961 and 1962. After 1962, milfoil declined in the Flats with slight increases in 1966 and 1967. Associated with the rapid increase in milfoil was a decline in other native species such as *Elodea, Najas* and *Vallisneria*. As milfoil declined, these species returned to approximately their former abundances (Bayley et al. 1978).

A third major period for SAV in the Bay was the decline of many SAV species in the early 1970s. Apparently the most widespread declines began in 1972, the year of Tropical Storm Agnes, although some personal accounts showed SAV declining in the 1960s especially in the Potomac and Patuxent Rivers. However, the intensive field survey by the Migratory Bird and Habitat Research Laboratory Survey, conducted from 1971 to 1978 in the middle and upper section sof the Bay showed the major changes occurring after the passage of Agnes in 1972 and in particular between the years 1972 and 1974.

The period of 1972-1974 represented what we feel is an unprecedented decline of eelgrass in some sections of the Bay. By 1978, many areas had a lower abundance of eelgrass than that present soon after the 1930s epidemic. A site on the York River at Mumfort Island typifies the above situation (Figure 2, Table 1), with grass increasing in abundance after 1937 and declining after 1971. No vegetation is now present, whreas, in the 1930s some still existed. Eelgrass is completely absent or found only in small, isolated patches in the Patuxent, Potomac, Rappahannock, Piankatank and York Rivers and from the mid-sections of the Bay from Smith Island to Eastern Bay. By comparing the historical and current information along with anecdotal accounts, it is apparent there has been a major shift in eelgrass distribution from the middle Bay zone to the lower Bay zone and from upriver areas to the mouth of the tributaries (Figure 3).

In addition to the two major periods that have seen large areas of SAV decline, there have been a number of localized declines that have occurred throughout the Bay. Some of these have been associated with dredging or shoreline construction activities (Orth 1978) while in another example, declines occurred adjacent to a steam electric generating station (Anderson 1969). Though quantitative documentation is inadequate, anecdotal information from local sources indicated that some SAV areas declined, apparently naturally, and then returned after a few years to previous levels of abundance.

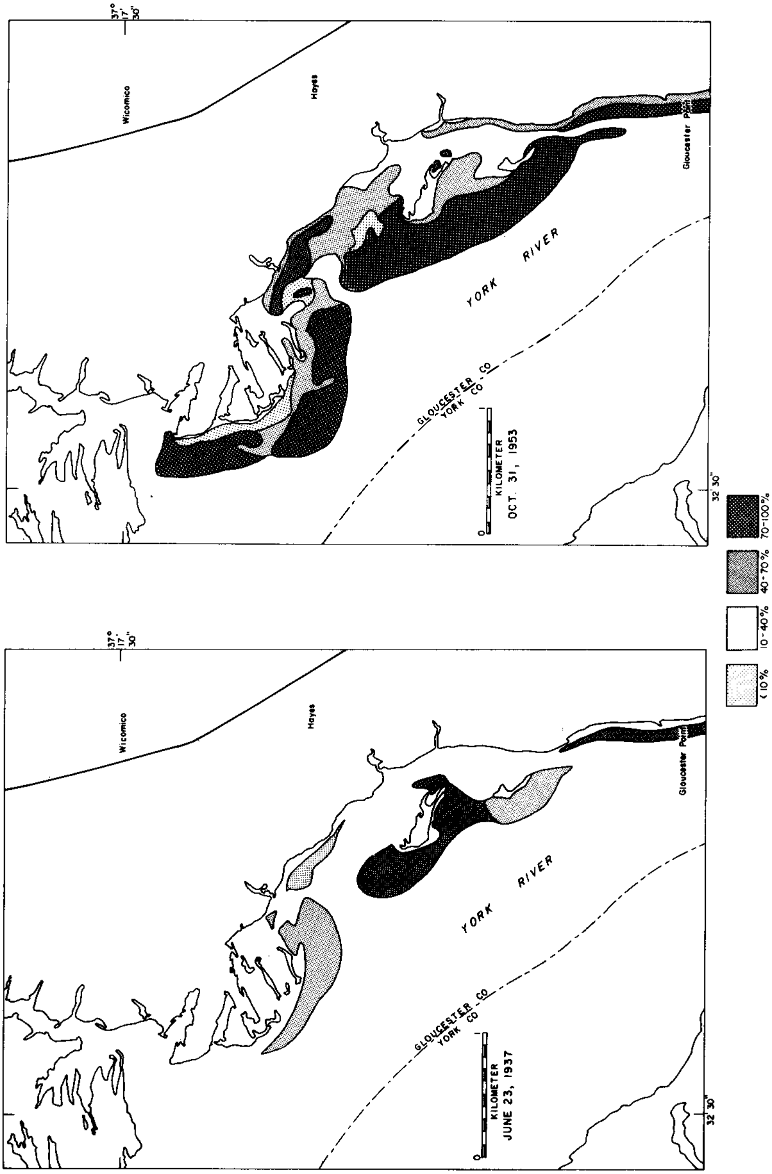
In the early 1930s the decline of SAV involved primarily eelgrass which was observed to have declined at the same time in many areas outside of the Chesapeake Bay region. With the 1970s decline, there is little evidence yet to suggest that a simultaneous decline has been observed in areas other than the Chesapeake Bay, and in contrast to the 1930s, today it appears that many different species and communities have been affected. In addition, evidence suggests that for eelgrass, the decline has been more severe with a less rapid recovery in the 1970s as compared to the 1930s.

The Future

For a prediction as to the future course of events for SAV abundance in the Chesapeake Bay, we must know the cause or causes of any decline from past levels, and whether they are acute or chronic factors. In addition, we must understand the numerous environmental factors such as light, temperature, salinity, nutrients, sediments, currents, etc. which control the growth and survival of SAV in the Bay and whether there has been a change in any of these so as to preclude existence of vegetation. This is no small task. In addition, we must understand the

Table 1. Changes in abundance of eelgrass at the Mumfort Island site from 1937 to 1978 for each of the four density classifications identified in Figure 2.

Date	Area in acres (hectares) <10%	10-40%	40-70%	70-100%	Total
1937	0	122.30(49.51)	98.15 (39.74)	5.89 (2.38)	226.34 (91.63)
1953	35.50(15.17)	172.72(69.93)	26.27 (10.64)	361.08(146.19)	595.57(241.93)
1960	0	63.78(25.82)	464.42(188.02)		528.20(213.84)
1971	0	169.33(68.55)	268.98(108.90)		438.31(177.45)
1974	0	31.49(12.75)	5.89 (2.39)		37.38 (15.13)
1978	0	0	0	0	0


Wicomico
Hayes
Gloucester Point
YORK RIVER
GLOUCESTER CO
YORK CO
0
KILOMETER
OCT. 31, 1953
JUNE 23, 1937
37° 17' 30"
32' 30"
<10%
10-40%
40-70%
70-100%

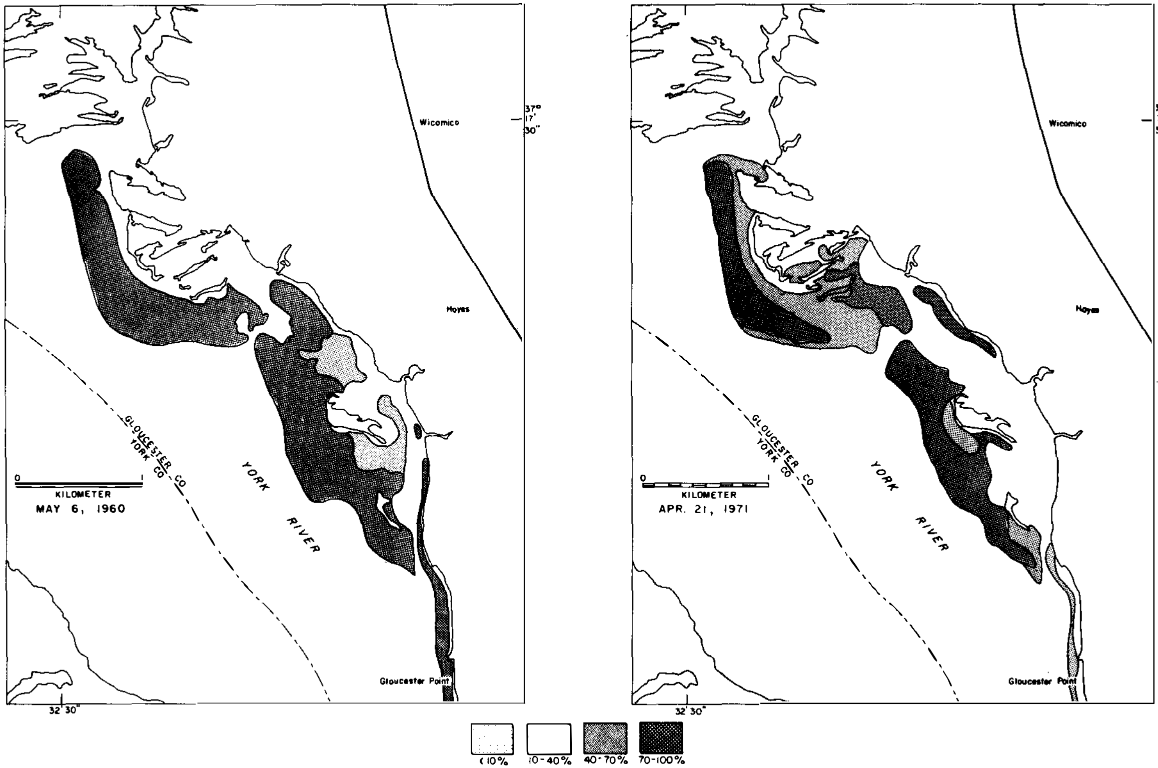


Figure 2. Changes in the distribution and abundance of SAV (primarily eelgrass) at Mumfort Island in the York River from 1937–1978 based on examination of historical aerial photographs. SAV abundance was classified into one of four categories based on an objective comparison with a crown density scale. These were very sparse (<10% coverage), sparse (10 to 40%), moderate (40 to 70%) or dense (70 to 100%). (Figure continued on page 280)

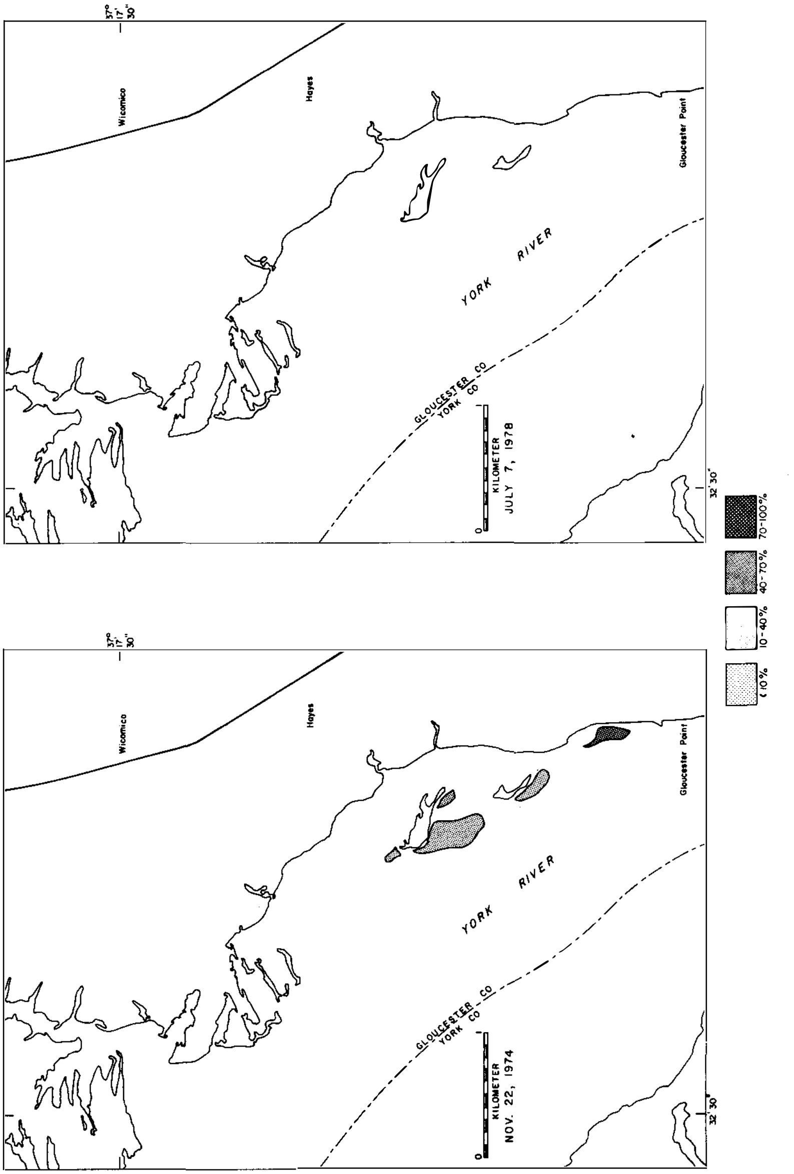


Figure 2. Continued

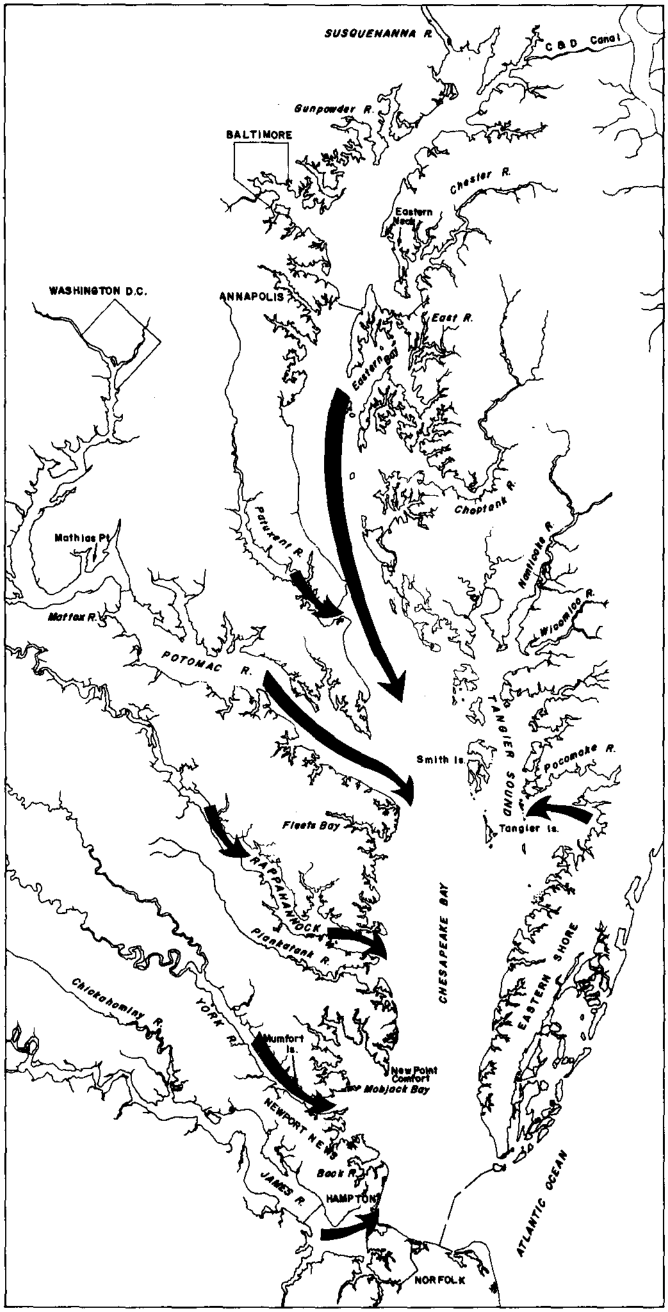


Figure 3. Map of the Chesapeake Bay showing recent changes in the distribution of eelgrass (*Zostera marina*).

fate and effects of man-made factors such as herbicides, which if found in sufficiently high concentration may act alone or synergistically with other stresses.

Complicating the problem further is the fact that SAV beds are generally quite sensitive to environmental perturbations and have a history of exhibiting rapid fluctuations in abundance. It is this sensitivity that is perhaps one of their values, an ability to act as an early alarm to continued deterioration in water quality. To determine if the recent declines in SAV abundance are an acute problem precipitated by a fluctuation in one or more environmental factors, or, more ominously, a permanent decline due to man-induced factors is one of the goals of the SAV portion of the EPA Chesapeake Bay Program.

As a first step in determining causative factors for the decline in SAV abundance, correlative information must first be documented. What factors are common to areas where the grasses have disappeared? What factors correlate with areas of continued abundance? It would appear that in the case of much of the Bay, areas of greatest recent decline occurred within the large, western tributaries such as the York, Rappahannock, Potomac and Patuxent as well as the Susquehanna Flats region at the head of the Bay and some of the subestuaries on the Eastern Shore, e.g. the Chester and Choptank Rivers. All of these areas receive considerable upland drainage, particularly during storm events. The occurrence of Tropical Storm Agnes in 1972 also correlates very well with the periods of most noticeable loss of vegetation. Speculation as to the implications of this event on increased turbidity and lack of light, stress of reduced salinity, etc. must await analysis of as complete a data set as possible.

It would appear from analysis of past distributional data that there is a finite amount of area suitable for establishment of SAV beds in the Chesapeake Bay. Other than the anomalous explosion of milfoil in the 1950s there is little evidence to suggest that SAV beds will occur in the future in areas other than where they occurred in the past. Thus there is little potential for the growth of SAV into new areas, but great potential for exclusion from established areas.

Fortunately, it appears that since 1978 the submerged vegetation has reached a steady state in abundance in most areas of the Bay and some sections have even shown a slight rebound. However, recruitment into the areas previously vegetated with lush stands of vegetation is extremely slow. Natural revegetation may be limited by lack of adequate reproductive stock as well as the self-perpetuating advantage of large vegetative beds which modify the sedimentary environments to reduce the resuspension of bottom material and act in other ways to minimize periodic stresses. Transplanting natural stock into these denuded areas may be the only way that these once densely vegetated areas could ever recover. This assumes that those factors that caused the initial decline have changed so as not to negatively affect the new material. Success with transplant experiments in the lower Bay indicate the potential for a possible replant program.

Our perception of the present situation and what the future holds is one of guarded optimism. We know that there have been past periods of decline of SAV in the Bay as well as worldwide and that some of these systems have apparently rebounded. Given the resiliency of the Bay ecosystem coupled with the proper understanding of the underlying factors that cause SAV species to fluctuate, and if an effective management program can be implemented to control man-made perturbations, these species have the potential to rebound successfully.

Acknowledgements

We would like to acknowledge the following people who have aided us in various ways in acquiring data on the distribution and abundance of SAV and understanding the changes that have occurred in the Bay with respect to SAV: Charlie Alston, Richard Anderson, Bert Brun, William Cook (project officer of the SAV program), Hayden Gordon, David Krantz, Robert Macomber, J. Court Stevenson, William Rhodes and Sam White. Work on the SAV systems in Virginia was funded by EPA Grants No. R805951 and X003201.

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Trends in Chesapeake Bay Fisheries

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Introduction

Commerical landings from Chesapeake Bay are reported from Maryland and Virginia waters. The Maryland-Virginia reported commercial landings have ranged from 93,000 to 334,000 metric tons a year with a dockside value of five to 62 million dollars. The recreational fishery is extensive, but poorly documented.

Large variations in annual landings are common. These have been variously attributed to natural phenomena, man-made environmental alterations, or fishing. Fish taken in Chesapeake Bay spawn in Bay tributaries, the Bay, or open ocean. Several Maryland-Virginia commercial species are restricted to or spend a portion of their early life history in Chesapeake Bay or other Atlantic Coast estuaries.

There has been growing concern in recent years that some fish stocks are declining to levels where recovery may not be possible. River herrings, American shad, striped bass, and soft-shell clams, key species in Chesapeake Bay fishery, are at their lowest catch levels since landings were first recorded in 1880. Conversely landings for other species including blue crabs and menhaden have been well above average for the last 10 years.

This paper is concerned with trends in Chesapeake Bay fisheries. We accordingly examine available Chesapeake Bay data on landings, effort, and catch-per-unit effort. We shall see that while we are able to consider trends in landings, information on effort and catch-per-unit of effort—the index of the actual abundance of the stocks—is often limited or not as yet available for recent years.

Catch History

Statistical records of Maryland-Virginia commercial fisheries were first collected in 1880 as part of a nationwide assessment of the fishing industry. The Maryland and Virginia catch comes from Chesapeake Bay and the Atlantic Ocean, off of Virginia and Maryland. Before 1952, catches in the Bay and in the Atlantic Ocean were not separated in the fisheries statistics, but after 1952, the catches from Chesapeake Bay could be separated from those taken in the Atlantic Ocean. We believe that the catches and fishing effort for the species that we have chosen to examine, however, relate predominantly to Chesapeake Bay.

The nationwide assessment and subsequent surveys, which included the Chesapeake Bay region, were compiled and published periodically from 1887 to 1929 and annually thereafter, with the exception of 1943. Power (1958) presented a bibliography of the series which included records of Maryland and Virginia for the period 1880 through 1956. Later reports were published as statistical digests of the U.S. Fish and Wildlife Service or the National Marine Fisheries Service titled *Fishery Statistics of the United States*.

Contribution No. 1133, Center for Environmental and Estuarine Studies of the University of Maryland.

The primary objectives of these surveys were to document for each state the number of fishermen, gear, and boats in the commercial fishery and the total weight of each species landed. These statistics were estimated for Maryland-Virginia fisheries from correspondence or interviews between state and federal personnel and large-scale commercial fishing operations, representative watermen, captains of licensed fishing vessels, wholesale fisheries firms, and packing and canning houses. All reports were obtained early in the calendar year for catches in the previous year (or season for oysters until 1931) and were based on the memory or catch records of the individual being interviewed.

This reporting procedure was modified when Maryland enacted legislation, effective January 1, 1944, which required all licensed commercial fishermen in the state to maintain and submit a record of each day's fishing (Hammer et al. 1948). These records were confidential between the fishermen and the cooperating state agencies and included the weight of each species landed, the location fished, the amount of fishing gear used, and the catch by gear type. Additional reports on unlicensed gear, excluding hook and line catches in Chesapeake Bay, were obtained as annual estimates through correspondence or personal interview. The returns from commercial fishermen were summarized by the Maryland Department of Research and Education and forwarded monthly to the U.S. Fish and Wildlife Service. Late reports and reports on unlicensed gear were summarized and submitted at the end of each calendar year. A synopsis of these records was published annually by the U.S. Fish and Wildlife Service. Published finfish and blue crab landings were presented as pounds whole weight while those for oysters and soft-shell clams were given as pounds of shucked meat.

Based on these data collection methods, the annual commercial catch was recorded from 1880 through 1979 for approximately 50 commercial species caught in Maryland and Virginia waters. In order to simplify our presentation we will present trends in catch and effort for 11 important Chesapeake Bay stocks. Of these, three are anadromous and five are migratory estuarine and marine fish species, plus oysters (*Crassostrea virginica*), blue crabs (*Callinectes sapidus*), and soft-shell clams (*Mya arenaria*). Related studies on Chesapeake Bay fish stocks have been conducted by, among others, Mansueti and Kolb (1953), Walberg and Nichols (1967), Koo (1970), Kohlenstein (1980), and Richkus et al. (1980a, 1980b).

Complementary recreational fishing data were included for five of the 11 species—striped bass (*Morone saxatilis*), Atlantic croaker (*Micropogon undulatus*), weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), and bluefish (*Pomatomus saltatrix*)—based on statistics collected by the Bureau of Sport Fisheries and Wildlife in 1960 and 1965 (Clark 1962, Deuel and Clark 1968) and the National Marine Fisheries Service in 1970, 1973-74 and 1979 (Deuel 1973, 1975, Anon. 1980). Because of the nature of the recreational fishery statistics, it was necessary to present catches for the Chesapeake Bay and its tributaries as part of the Middle-Atlantic Region, which extends from the northern border of New Jersey south to Cape Hatteras, North Carolina. In addition, general statistical coverage of the recreational fishery is available only at five-year intervals.

American shad (*Alosa sapidissima*); the combined species of river herrings, the alewife (*Alosa pseudoharengus*), and the blueback herring (*Alosa aestivalis*); and striped bass (*Morone saxatilis*) have historically accounted for most of the harvest of anadromous species in the Chesapeake Bay.

American shad landings have steadily declined from 8,100 metric tons in the late 1800s to a low of about 500 tons in the late 1970s (Figure 1A). Stocks were reduced to the point where commercial fishing for this species was banned in 1980 for the first time in the history of the fishery.

River herrings landings also reached an all-time low in recent years (Figure 1B). Prior to 1976, catches were consistently between 5,000 and 18,000 metric tons a year, with the exception of 1909 and 1910 when peak harvests of 23,000 and 30,000 metric tons were reported. The annual catch from 1976 through 1979 was approximately 1,000 to 2,000 metric tons a year.

Similarly, a sharp decline in commercial striped bass catches was reported from 1974 through 1979 after approximately 35 years of increasing harvest (Figure 1C). Landings in 1979 were only slightly higher than reported catches for 1934, which was the lowest year on record. Based on preliminary commercial records, a slight increase over the 1978 and 1979 harvest occurred in 1980.

A decline in the striped bass catch was also reflected in the recreational fishery. Total weight of the catch, number of fish caught, and average catch per angler were the lowest on record in 1979 (see Figure 3A). Landings in that year were 1,200 metric tons, well below the mean catch of 6,200 metric tons for the 20-year survey period.

The fishery for the predominantly offshore spawners has historically been dominated by Atlantic menhaden (*Brevoortia tyrannus*), Atlantic croaker (*Micropogon undulatus*), weakfish (*Cynoscion regalis*), and spot (*Leiostomus xanthurus*). Long-term catches of these species should be considered with regard to a statistical reporting modification implemented by the U.S. Fish and Wildlife Service in 1942. Since that year, the catch of a vessel (craft five net tons and larger) has been credited to the port where it was offloaded rather than the previous practice of reporting the catch of a particular vessel for the entire year to the port where most of the catch was unloaded. Although this change increased the reliability of catch records, the location where the landings were actually caught was still not taken into account.

Historically, Atlantic menhaden have accounted for most of the Chesapeake Bay finfish catch, although it should be noted that, by regulation, menhaden can now only be taken in most fishing gears in Virginia waters. Landings followed two parallel trends of increasing abundance, the first of which began in 1880 and the second in the early 1940s (Figure 1D). These were separated by a period of sharp decline after 1920. Harvests in recent years were the highest in history, approaching 250,000 metric tons in 1972.

The commercial Atlantic croaker fishery was most productive from 1920 through 1947 (Figure 1E). Landings increased steadily from 1930 to 1937 then remained at a historically high level of 15,000 to 26,000 metric tons for the next ten years. After 1947, landings declined and have consistently been below 5,000 metric tons a year since 1958. Recent catches were approximately the same as those for the late 1800s.

Recreational landings of Atlantic croaker have steadily declined since 1960 and have been below the 20-year average of 1,800 metric tons since 1965. The total number of fish caught, the average catch per angler and the total weight of the catch were lowest in 1979 (see Figure 3B).

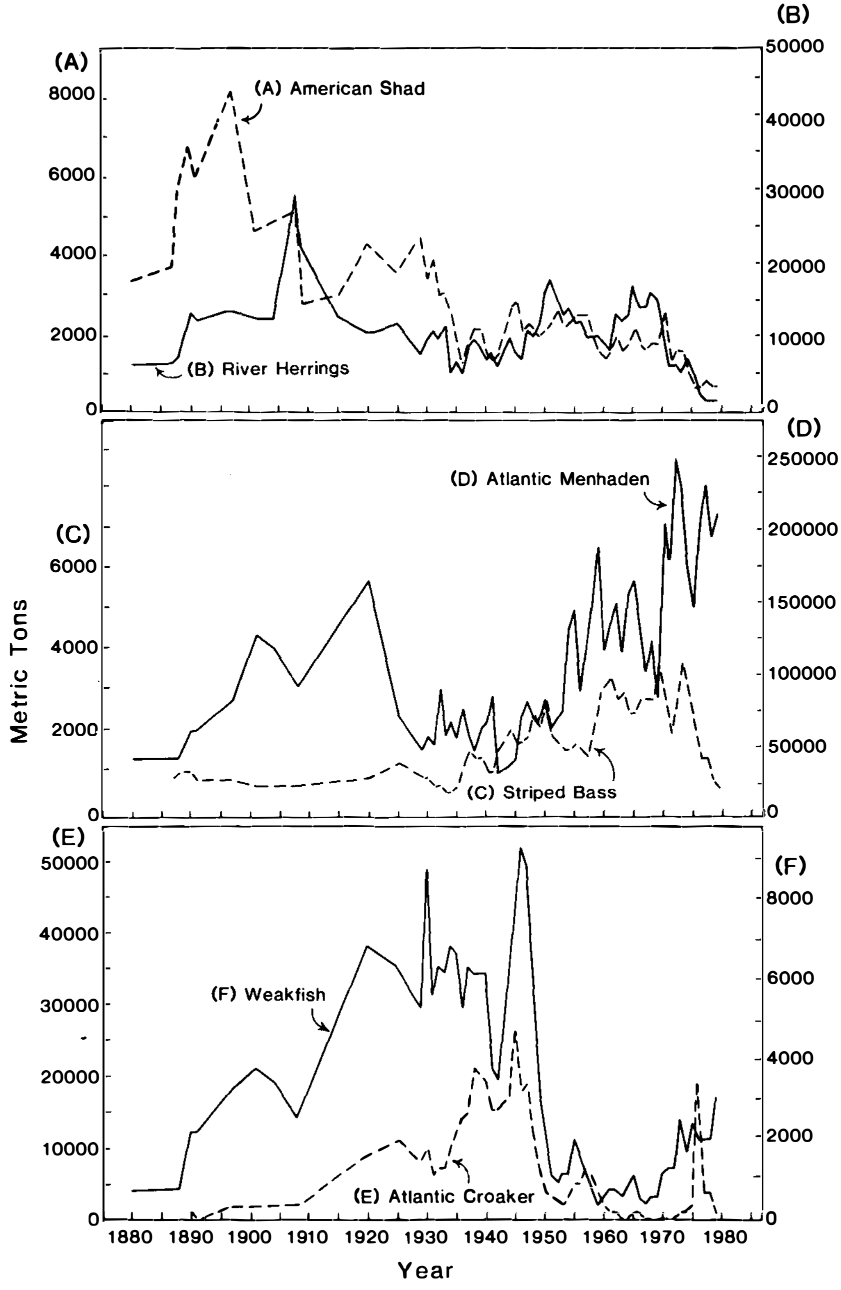

Figure 1. Commercial landings of (A) American shad, (B) river herrings, (C) striped bass, (D) Atlantic menhaden, (E) Atlantic croaker and (F) weakfish in Chesapeake Bay and Atlantic Ocean waters of Maryland-Virginia from 1880-1979.

Commercial weakfish harvests increased from 700 metric tons a year in the late 1880s to historically high levels of 5,200 to 9,700 metric tons a year for a 21-year period which began in 1920 (Figure 1F). Landings fluctuated markedly from 1941 through 1960 then remained relatively constant for about ten years at the 1880s level. Harvests have steadily increased since 1970.

Based on the lack of recreational catch records for weakfish in 1960, landings for this species may have been extremely low during that period. The weight of the catch increased consistently from 1965 through 1973-1974 and declined in 1979, averaging 4,400 metric tons for the 15-year survey period (see Figure 3C).

Commercial spot landings have fluctuated extensively throughout the history of the fishery with the exception of catches recorded prior to 1925 (Figure 2A). During the period 1944 through 1960, catches were consistently high, ranging from 1,600 to 4,200 metric tons annually. Landings in recent years have varied from about 3,000 metric tons in 1970 to 200 metric tons in 1971.

Recreational spot catches were highest within the 20-year survey period in 1970 when 33 million spot weighing nearly 10,000 metric tons were landed (see Figure 3D). The weight of the spot catch declined over the next two survey periods to a survey low of 425 metric tons in 1979, well below the 20-year average of 3,500

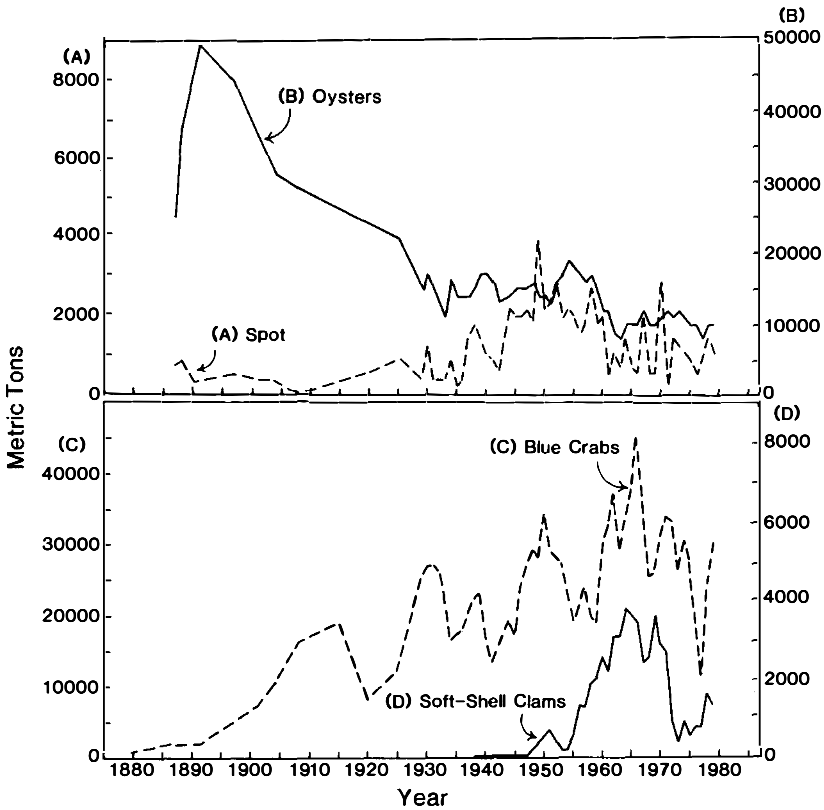

Figure 2. Commercial landings of (A) spot, (B) oysters, (C) blue crabs, and (D) soft-shell clams in Chesapeake Bay and Atlantic Ocean waters of Maryland-Virginia from 1880-1979.

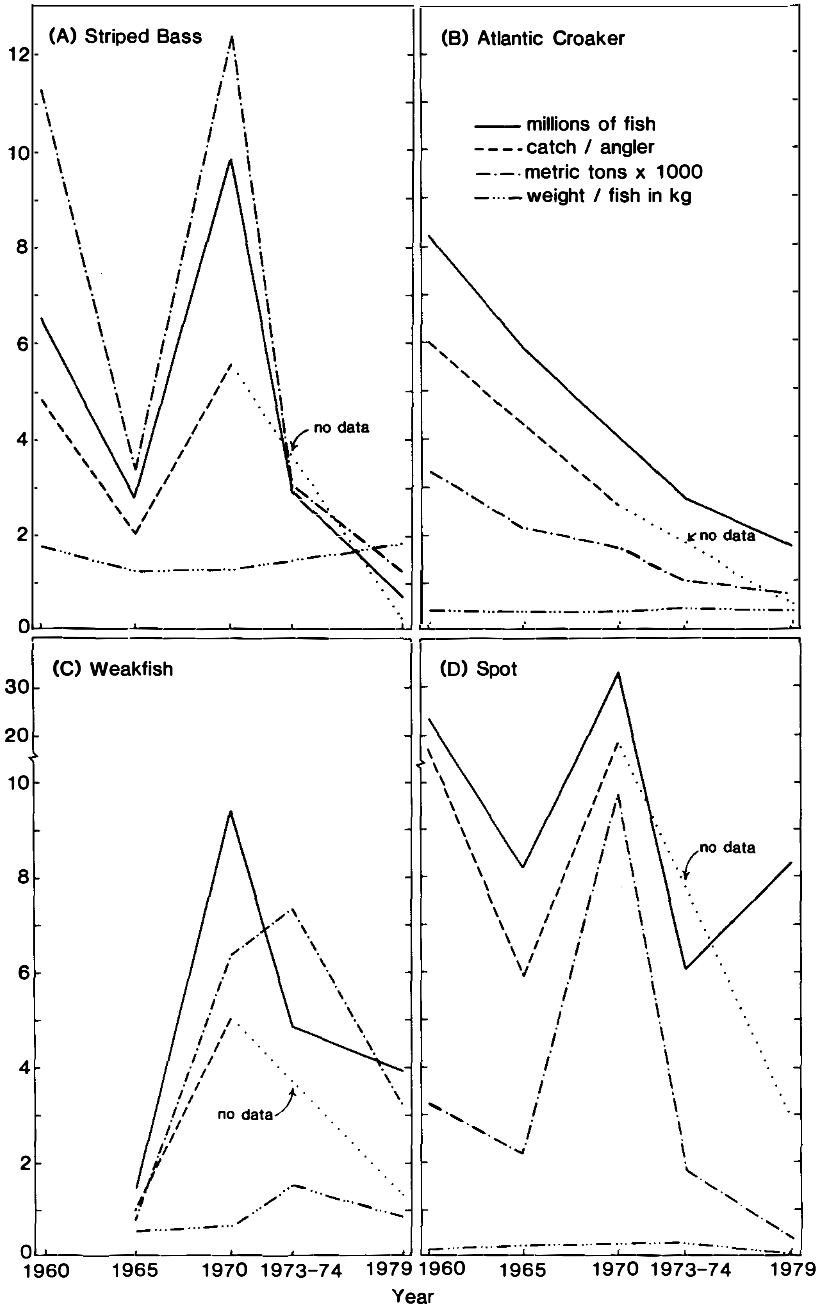

Figure 3. Recreational landings of (A) striped bass, (B) Atlantic croaker, (C) weakfish, and (D) spot from the northern border of New Jersey to Cape Hatteras, North Carolina for the period 1960-1979.

metric tons. However, because sportsmen apparently elected to keep smaller fish, the number of spot caught in 1979 increased significantly from the 1973-1974 level.

Although bluefish have not been an important commercial species, recreational fishing in recent years has been extensive. Landings ranged from 7,000 metric tons in 1965 to 32,000 metric tons in 1973-1974 and averaged 16,000 metric tons over the 20-year survey period.

Oyster harvests peaked during the 1884-1885 season when approximately 15,000,000 bushels yielded 49,000 metric tons of meat (Figure 2B). Landings declined thereafter through 1929, then became stable at about 15,000 metric tons for the next 22 years. After a slight increase to 19,000 metric tons in 1954, harvests consistently decreased for a period of nine years, then stabilized at the current harvest level of about 11,000 metric tons a year.

Blue crab landings have generally increased from the 1880s through the middle 1960s but have been subject to extensive fluctuations within relatively short periods of time (Figure 2C). Landings reached a high of 45,000 metric tons in 1966 and were about one-half of that value two years later. Peaks in harvest, followed by a number of years in which landings declined, were recorded in 1930, 1950, and 1966.

The soft-shell clam fishery developed in the early 1950s as a direct result of the introduction of the escalator dredge into the Chesapeake Bay region. Harvests increased steadily thereafter through 1964 when 3,700 metric tons of meats were reported (Figure 2D). Landings fluctuated between 2,500 and 3,500 metric tons during the next seven years and declined sharply after 1971. Recent landings have ranged between 300 and 1,600 metric tons a year.

Recent Trends in Actual Chesapeake Bay Catches

Since 1952 the statistical collection procedures enable separation of Chesapeake Bay catches from those of the adjoining Atlantic Ocean. We have accordingly normalized these statistics as the percent deviation from the mean catch, thus placing all trends in catches on the same scale (Figure 4).

The commercial harvests of the majority of these species have frequently been below average in recent years. Atlantic croaker, spot, and oyster landing declines began in 1959 or 1960 (Figure 4A–C), followed by American shad, river herring, and soft-shell clams in 1970 or 1971 (Figure 4D–F). Current striped bass landings have also been below average, continuing a trend that began in 1975 (Figure 4G).

Conversely, reported harvests of Atlantic menhaden and weakfish have been above the mean in each year since 1970 or 1971, reversing a long-term trend of below average catches (Figures 4H–I). Weakfish represent the sole species with steadily increasing landings in recent years.

Blue crab landings were unique in that they consistently fluctuated near the mean throughout the survey period (Figure 4J). Catches were slightly below average throughout the 1950s, generally above in the 1960s, and again somewhat below in the 1970s. The sharp decline in 1977 was one of the most extreme departures from the average catch in the 28-year survey period.

Fishing Effort

The previous section discussed trends in Chesapeake Bay landings. For some of the species, particularly the anadromous fishes, catches have tended to decline.

For others, primarily the off-shore spawners, catches have tended to increase.

Information on trends in catches however, may or may not reflect changes in the stock sizes of the fish. If fishing effort (more properly fishing mortality) declines, and stock size remains roughly stable, one would expect to see a decline in catch. The converse is, of course, true. Thus, declines in catch may reflect a decline in the population or simply a decline in the amount of fishing effort.

The analysis of fishing effort is ordinarily a complicated task (Rothschild 1977). This is because fishing effort is generally measured in nominal units. For example,

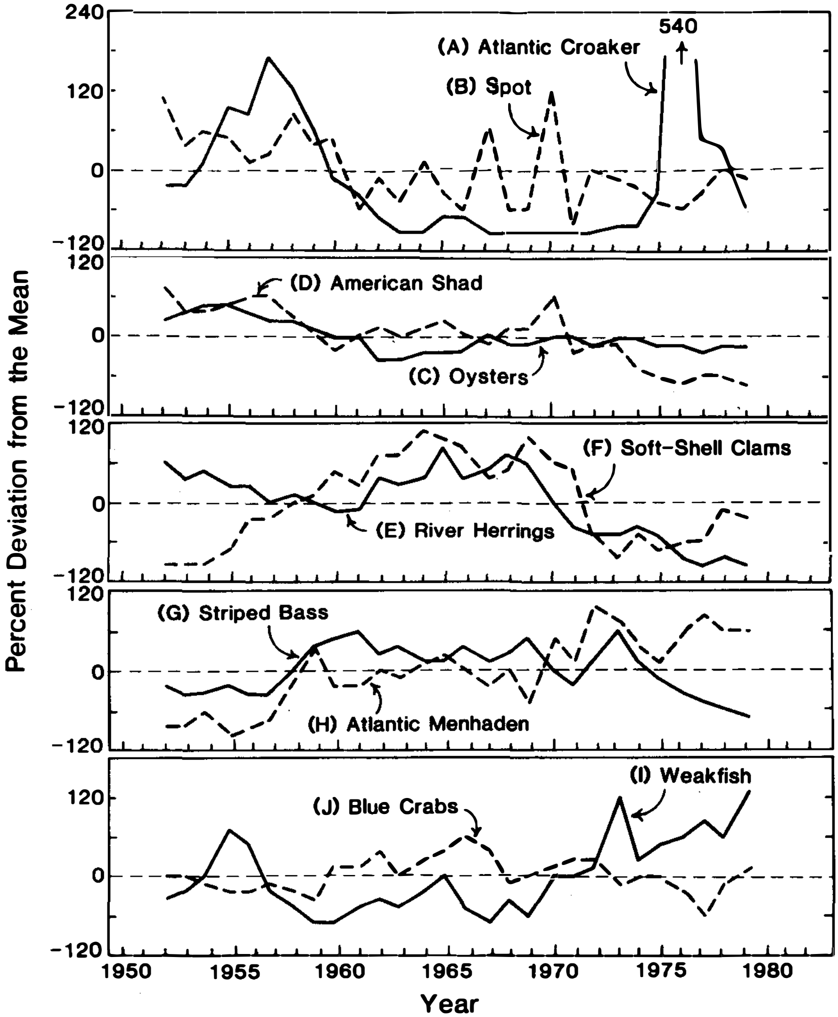

Figure 4. Annual Chesapeake Bay commercial landings of (A) Atlantic croaker, (B) spot, (C) oysters, (D) American shad, (E) river herrings, (F) soft-shell clams, (G) striped bass, (H) Atlantic menhaden, (I) weakfish, and (J) blue crabs from 1952-1979, expressed as a percent deviation from the mean.

fishing effort may be measured in terms of the number of boats fishing, the number of boats fishing per unit-of-time, the number of nets, or the square yards of gill net set. The response of the population needs to be measured in units of fishing mortality and not necessarily in units of nominal fishing effort. Technically, fishing mortality is the fraction in number of the average annual population that is removed by fishing. The link between fishing effort and fishing mortality may be straightforward, but, on the other hand, it may also be complex. The complexity usually arises when the fishing-effort units exhibit the possibility of generating widely different amounts of fishing mortality. Thus, a unit of nominal fishing effort such as the number of hours fished by a gill net of a specified area, netting material, and mesh size would generally be a much more precise measure of fishing mortality than simply the yards of gill net that are registered to fishermen in any one year.

The great majority of fishing effort that is recorded, often in some detail for Maryland-Virginia, tends to be more of the imprecise type rather than that which is easily related to fishing mortality. The reasons for this often relate to the collection of the less desirable kinds of effort statistics. Furthermore, the effort statistics contain some effort expended beyond Chesapeake Bay in the Atlantic Ocean waters of Maryland and Virginia. However, we believe that since most of the gear discussed relates primarily to Chesapeake Bay fisheries, the amount of gear fished in the Atlantic Ocean and reported here would tend to be minimal. This same observation would apply to the subsequently discussed catch-per-unit-effort statistics.

Nevertheless, rather than assume that fishing effort is constant and that catches simply reflect the changes in the abundance of stocks, we will endeavor to examine some trends in effort statistics, however crude they may be at this time, and try to add to our knowledge of the changes in stock abundance.

The fishing effort statistics for Maryland-Virginia were extracted from the same sources used for catch data, i.e., Fisheries Industries of the United States, annually, from 1929 through 1938, and Fisheries Statistics of the United States, 1939 through 1975, except 1943.

Measures of fishing effort range from gross indices (numbers of boats and boat tonnage) through numbers of fishing gear by type (pound nets, haul seines, etc.) to some quantitative measures of the licensed area or amount of certain gears (haul seines, area trot line baits, gill net area, dredge and scrape area).

The effort data also varies from species-specific gear such as crab and eel pots through non-species-specific finfish gears (pound nets), to very general indicators of fishing intensity (boat numbers and tonnage).

The most useful type of fishing-effort data would report the actual amount of a specific type of gear which was fished for a specific period of time. This information, when related to the catch taken, yields a measure of the catch-per-unit effort for the fishing period. We believe that time series of detailed effort data of this nature are not available for Chesapeake Bay.

The annual statistical summaries present the maximum number of operating units surveyed or licensed in the reporting year. There seems to be no readily available information on the actual amount of any specific gear used per day nor of the mean amount of gear used per month or year.

The effort information issue is further complicated by changes in the reporting units or methods for specific gears. Indications of the area or amount of fishing gear licensed as contrasted with the number of licenses of a gear type are not reported in fisheries statistics of the United States after 1970.

Pound nets were reported as numbers only through the period. Haul seines are reported as numbers throughout the period and as length in yards from 1929 through 1970.

Gill nets were reported as numbers and area (square yards) for stake or set, anchor and drift nets from 1929 through 1960. In 1961, set, anchor-and-stake gill nets were combined, but still reported as numbers and area. The report of square yards of netting for all types of gill net ended in 1970, while reports of number continued through the remainder of the period.

The fishing gear examined in the blue crab fishery includes trot lines, crab pots, and dredges. Data for trot lines include both the numbers of lines licensed and the total number of baits. These two records are continuous from 1929 to 1975. Crab pots are reported as numbers from 1935 through the rest of the period. Crab dredges are reported as numbers and opening (yards at mouth).

The oyster gear consists of oyster dredges and tongs. Oyster dredge data are available in numbers and opening (yards at mouth) throughout the period. Osyter tong information is reported as numbers.

Figure 5 presents time series for various reported units of nominal fishing for Maryland-Virginia. In order to provide the reader with an appreciation for the trends in effort, the graphs show time series plotted as percent deviation from the mean. Therefore, the trends are all presented on the same scale, normalized to the mean amounts of nominal effort expended.

Figure 5A–B shows the time trends in pound nets and haul seines. We can see a consistent decline in the number of pound nets. A decline in the post-war years in the area of haul seines is also evident. In the early years of the time series, pound nets and haul seines took significant quantities of striped bass and American shad.

Figure 5C–D shows the time trends for stake-and-anchor gill nets and drift gill nets. These figures relate to the square yards of net and while the drift gill nets have been decreasing in the post-World War II years, the stake-and-anchor gill nets have been increasing. The total yardage of both kinds of nets combined appears to be constant. However, since these nets fish in a different way in different locations, relative contributions to fishing mortality are not clear.

Figure 5E–F shows the time series for oyster dredges and oyster tongs, and we can see that quantities of these gears over time have tended to decline in the post-war years.

Figure 5G–I shows the time trends for crab pots, crab dredges, and trot lines. The quantity of crab pots has increased considerably since the 1940s. Crab dredges likewise increased until about 1960, but then have declined; whereas trot lines have increased dramatically in the 1970s. The crab dredges are used mostly in Virginia waters and concentrate on the winter fishery for female crabs.

Apparent Abundance

In previous sections we have discussed trends in both the catch and fishing effort for Maryland-Virginia and for Chesapeake Bay. Because the catch is often made with different types of gear, it is infeasible to simply divide the catch by non-

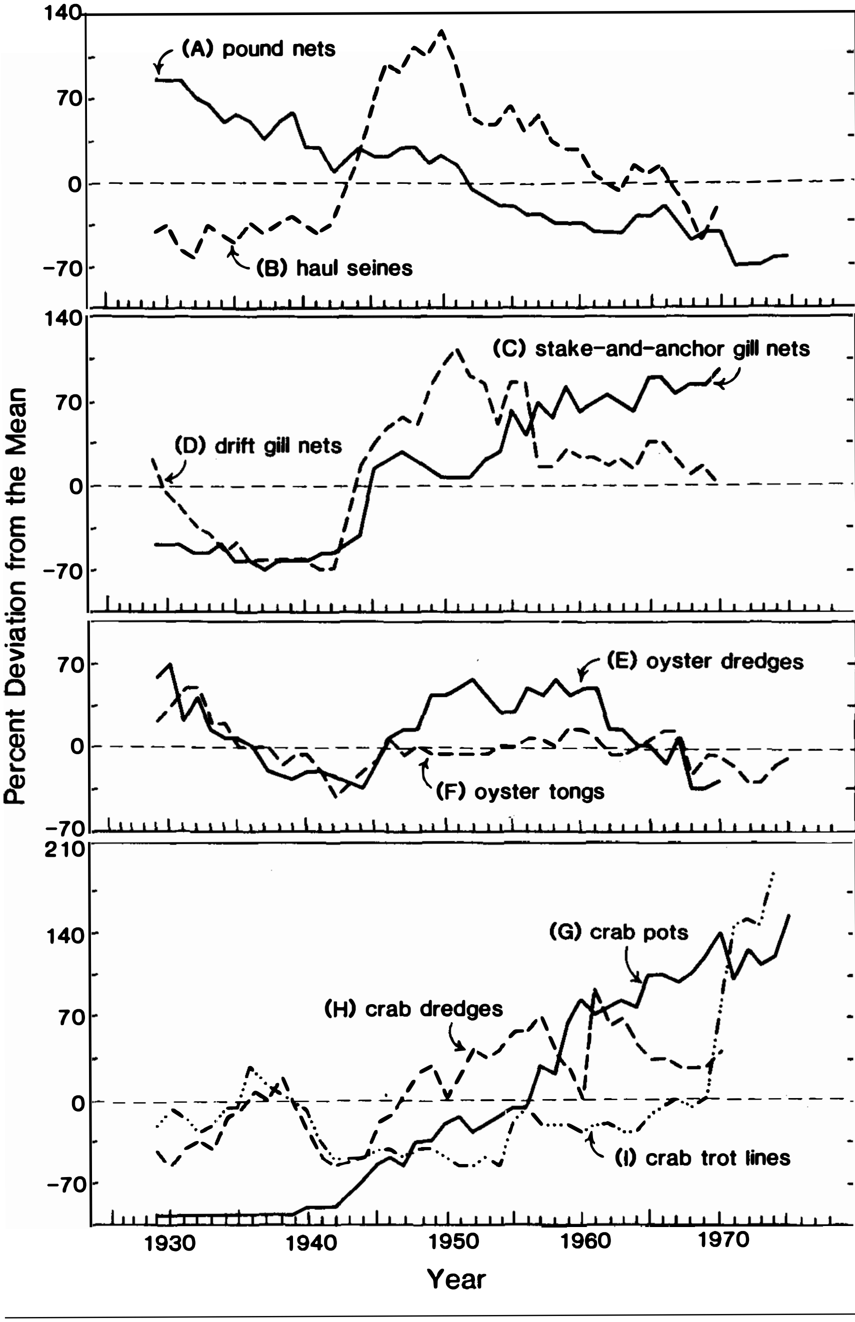

Figure 5. Time series of fishing effort for (A) pound nets, (B) haul seines, (C) stake-and-anchor gill nets, (D) drift gill nets, (E) oyster dredges, (F) oyster tongs, (G) crab pots, (H) crab dredges, and (I) crab trot lines, expressed as a percent deviation from the mean.

standardized effort in order to determine the apparent abundance of fish. There are, however, some data sets that report the catches for specific types of fishing gear. We will use these catch-per-units of effort as a rough index of abundance since even within certain types of gear, such as gill nets, catchability may and probably does vary considerably. We should also note that at the time of preparing this paper certain complete time series of catch-per-unit of effort were not available. For example, gill net catch-per-unit of effort of striped bass was avaialble only up until 1970. Further, for the purpose of this analysis, we consider trends in abundance of only three of the 11 species of concern.

Figure 6A–B shows the apparent abundance of striped bass in terms of the catch-per-unit of effort in both stake-and-anchor and drift gill nets. We can see that the apparent abundance as indicated by these two gears is roughly similar. Striped bass were relatively abundant in the late 1930s and early 1940s as well as in the early 1960s. The abundance in the decade of the 1960s was relatively high. While not having the catch-per-unit of effort data for the 1970s, there is a general belief that the stocks of striped bass for this period were at a relatively low level.

The apparent abundance of striped bass as indicated by pound nets is also included in Figure 6C. We see again a rough correlation between the apparent abundance as indicated by pound nets and that indicated by stake-and-anchor gill nets and drift nets. We conclude that over the time series for which data are available, striped bass exhibit two peaks in apparent abundance, one in the late 1930s and another in the decade of the 1960s. Over the period of consideration, pound net and haul seine effort has been decreasing while gill net effort has generally tended to increase or remain stable. Thus, not knowing the relative effectiveness of these fishing gears, it is not clear whether fishing mortality has increased or decreased. Hence, the relation between fishing effort and apparent abundance of striped bass in Chesapeake Bay is not yet certain.

The apparent abundance of American shad as indicated by stake-and-anchor gill nets and drift nets is indicated in Figure 6D–E. Again, these two types of gear reflect over the period of consideration a rough correlation. In other words, there were peaks in apparent abundance in the late 1920s, the mid 1950s and in 1970. It is generally believed that the American shad have declined sharply since 1970. The American shad is caught predominantly with gill nets, and since the square yards of reported gill-net effort over this period have remained roughly constant, it would seem that there is a real decline in American shad abundance.

The apparent abundance of blue crab as indicated by crab pots, trot line baits and crab dredges is indicated in Figure 6F–H. We can see that there is a consistent decline in apparent abundance as indicated by both crab pots and trot line baits. The catch-per-unit of effort, however, of crabs caught with dredges has increased in the 1960s. The explanation for this difference is not yet clear; however, it should be noted that the dredges basically take females, while pots or trot lines take both males and females. The dredges fish primarily in the wintertime for female crabs buried in the bottom sediment of the lower Bay.

Discussion

Thus, the past, present, and future of Chesapeake Bay fisheries can be viewed from several vantage points. These include the condition of the stocks, the status of stock assessment, the ability to manage the stocks of the Bay, and the nature of the institutions that are involved in Chesapeake Bay fisheries management.

With respect to condition of the stocks, it appears on the basis of trends in catch and limited information on effort and catch-per-unit of effort, that the anadromous stocks are declining while some coastal-spawning stocks are increasing in abun-

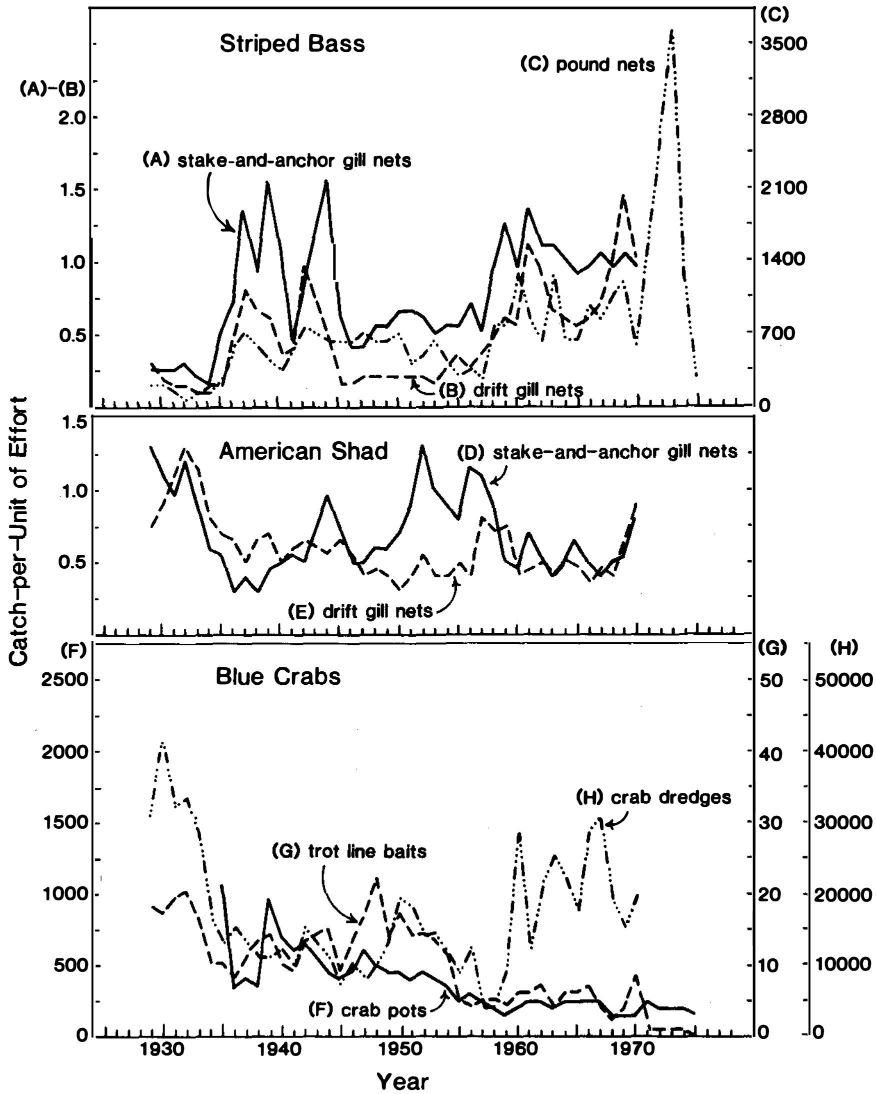

Figure 6. Catch-per-unit of effort, expressed in pounds of striped bass caught, (A) per square yard of stake-and-anchor gill net, (B) per square yard of drift gill net, (C) per pound net; American shad caught, (D) per square yard of stake-and-anchor gill net, (E) per square yard of drift gill net; and blue crabs caught, (F) per crab pot, (G) per trot line bait, and (H) per yard of crab dredge.

dance. The degree to which this generality holds will depend upon more detailed analysis particularly with regard to the striped bass.

As with all fish stocks, the future abundance of those in Chesapeake Bay are subject to the vagaries of nature. On the other hand, there are beliefs that many of the apparent downward trends in stocks owe to man-made changes to the habitat or the environment or to fishing. While there is no doubt that there are many changes in the Bay ecosystem that relate to increased habitation of its shores, the exact linkages between the environment and the fish stocks are as yet uncertain. These linkages have been virtually ignored in studies of Chesapeake Bay. Further, the condition of fishery statistics makes it difficult to determine, with any certainty at this point in time, the effects of fishing or the productivity of the stocks.

The primary concern with respect to Chesapeake Bay stocks involves the quality of Bay-wide fishery-management decisions. These management decisions or a lack of management decisions, which are, in effect, implicit decisions not to decide, are made on a daily basis. But, are these decisions the best that can be made? Are they consonant with one another, and do they lead to overall improvements in the fisheries?

To answer these questions, basic information is required on the status of the stocks—their recruitment patterns, their yield-per-recruit structure, their productivity and the degree to which these variables depend upon environmental changes. It is fair to say that for Chesapeake Bay fisheries information on these subjects is scarce and, as a consequence, little can be said about the effect of pollution, habitation or fishing upon the status of the stocks. While there have been ample studies of the modification of the Bay waters, there has not been a comparable effort in measuring fish-stock abundance.

In addition to the incompleteness of data, analyses of the trends in abundance and the effects of fishing are necessarily superficial because for most species there has been little work on growth functions, estimates of natural mortality, estimates of fishing mortality and estimates of recruitment.

Without these analyses, it is no simple task to discern the effects of fishing or indeed the effects of the environment in the absence of an analysis of the effects of fishing. It is absolutely essential to develop a Chesapeake Bay-wide coordinated program to assemble in a timely fashion the catch, effort, apparent abundance and size at age data from the fishes of the Bay. One of the biggest problems with respect to catch data is the question of the timeliness, and the assessment of the magnitude of the substantial recreational catch. With respect to fishing effort, a major difficulty is that in its present form it is too crude for detailed analyses. Gill net data, for example, should be recorded by sizes of net, mesh size and hours fished. With respect to growth, size and age determinations for many of the fish in Chesapeake Bay need to be refined and where necessary supplemented by new observations. Assembling these statistics would facilitate the study of production and yield-per-recruit so that the effects of fishing both with respect to fishing mortality and the size which are optimal to capture can be determined.

Fortunately, programs such as these are now being contemplated by the States of Maryland and Virginia. It is essential to provide a forum for determining the scientific basis of the status of stocks in Chesapeake Bay and to develop coordinated efforts which will give us a much-improved knowledge of the trends in

Chesapeake Bay fisheries stocks. A model for such an institution is the highly successful California Cooperative Fisheries Investigations.

Thus, the very ability to manage the stocks of the Bay is limited by information on the stocks of the fish. As indicated earlier, the states have a new awareness of the problem and they will hopefully develop a joint statistical system for Chesapeake Bay fisheries. Such a system will not in itself determine the future of the fisheries of the Bay, but it will enable those who fish or otherwise utilize or interact with the resources of the Bay to have at least a better than even chance to affect the future of Chesapeake Bay fish stocks.

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Twenty-five Year Trends in Diving Duck Populations in Chesapeake Bay

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Introduction

The Chesapeake Bay, with its extensive and varied wetland habitats, has historically been a major wintering area for many of the continent's migratory waterfowl (Anatidae). An estimated 1.5 million waterfowl winter in Chesapeake Bay every year between October and April. These birds comprise 35 percent of the total waterfowl wintering in the Atlantic Flyway from Maine to Florida, and about 15 percent of the diving ducks in the Atlantic Flyway. A mild climate and broad, ice-free shoal areas with abundant natural foods make the Bay an attractive wintering area for diving ducks. The Bay also provides many resting areas in protected estuarine bays and rivers. Chesapeake Bay waterfowl have historically been of keen interest to sportsmen and nature lovers who have been acutely aware of changes in the distribution and abundance of their favorite species.

Many factors are responsible for annual changes in migratory waterfowl populations. The causes of these fluctuations in populations are complex and often difficult to investigate. Natural phenomena (e.g., water conditions on the breeding grounds) result in annual fluctuation of waterfowl production. Mortality due to disease, weather, and other natural causes can further alter populations. Hunting regulations are evaluated and can be changed yearly in response to natural production. For some species like the mallard (*Anas platyrhynchos*), hunting mortality seems to have little impact on populations and is generally considered to be a compensatory rather than an additive mortality factor (Anderson and Burnham 1976). The effect of hunting mortality on diving duck populations is less clearly understood (Patterson 1979, Nichols and Haramis 1980).

Adequate censusing of the numbers and distribution of diving ducks using the Bay from year to year has been important to management. Aerial surveys have been of particular value because of the tendency of diving ducks to concentrate in large numbers in open water habitat where they can be readily observed. These surveys were developed by the U.S. Fish and Wildlife Service in cooperation with the states to assess the relative numbers of wintering waterfowl in various regions of the United States (Larned et al. 1980). Major habitat changes have occurred in the Bay area in recent years. Vegetation surveys conducted by the U.S. Fish and Wildlife Service, the Maryland Department of Natural Resources, U.S. Geological Survey, and the Virginia Institute of Marine Science have shown a decline in the distribution and abundance of submerged aquatic vegetation in Chesapeake Bay (Kerwin et al. 1976, Bayley et al. 1978, Orth et al. 1979, Carter and Haramis 1979). Turbidity and herbicides are among the many factors that have been implicated in the decline of vegetation (Stevenson and Confer 1978).

The purpose of this report is to examine population trends of diving ducks in Chesapeake Bay as reflected in 25 years of aerial waterfowl surveys and to discuss factors affecting these trends.

Methods

Aerial waterfowl surveys have been conducted by the U.S. Fish and Wildlife Service and cooperating states in early January since 1948 in all major wintering habitats in the United States. In January, population distributions are generally more stable and concentrated than at other times during the winter. Only data from 1955 to 1979 were analyzed in this report, as survey boundaries before 1955 were too variable. Chesapeake Bay populations are represented by the combined totals from the Maryland and Virginia sections of the Bay. Scaup (*Aythya* spp.) and scoter (*Melanitta* spp.) are not usually identified by species, and in this report counts of the two scaup and three scoter species are combined by genera. Data used in this report do not include populations of birds wintering in Canada or Mexico. These data, therefore, may be used to estimate distribution and abundance of wintering waterfowl in the United States that may or may not reflect the continental status of some waterfowl species. All survey data used in this report were obtained from unpublished data in files of the Office of Migratory Bird Management, U.S. Fish and Wildlife Service (USFWS), Laurel, Maryland.

Surveys were flown at low levels (25-100 m) with single engine aircraft of the U.S. Fish and Wildlife Service and various state wildlife agencies. In Chesapeake Bay, all tidal shoreline areas were flown about 100-500 m from shore and all waterfowl on both sides of the aircraft were visually estimated. The plane is usually flown to enable the observer to estimate the number of birds near shore and the pilot to estimate waterfowl occasionally seen in deeper water. In areas where birds are widespread or in high numbers, several passes are made to assure coverage and improve accuracy. Survey techniques used in other areas of the United States are similar to those used in Chesapeake Bay.

Attempts were made to reduce variability of estimates by using experienced observers and minimizing personnel changes. In spite of some inherent biases, winter survey data provide an indication of waterfowl distribution and relative abundance (Larned et al. 1980). Waterfowl populations on the breeding grounds are also surveyed by the U.S. Fish and Wildlife Service; these surveys result in population estimates that are considered to more adequately represent the status of certain species (Martin et al. 1979).

Linear regression analyses (Graybill 1976) were conducted using 25 years of survey data for 7 species. Auto-regression analyses (Box and Jenkins 1976) were also conducted to examine the auto-correlation in the data. Since significant auto-correlation was not found, ordinary linear regression analyses were considered satisfactory. Annual rates of change were determined using simple linear regression for three areas (Chesapeake Bay, Atlantic Flyway, and the United States) and for three time periods (1955-79, 1970-79 and 1975-79). Probability levels of 0.01 and 0.05 were chosen for determining statistical significance of these rates. Survey data in graphs are presented as 3-year running averages to minimize annual fluctuations and emphasize long-term trends.

Food habits data for diving ducks have been previously summarized for certain years (Cottam 1939, Martin and Uhler 1951, Stewart 1962, Rawls 1978). All available food habits data for waterfowl of Chesapeake Bay from 1890-1979 were recently summarized (Munro and Perry 1981). Food habits data used in this report were taken from these previous reports. Additional food habits data for ruddy ducks (*Oxyura jamaicensis*) and scoter were obtained from unpublished USFWS files and are based on small samples of birds.

All food habits data result from gizzard analyses and are used to show trends in food habits over many years, recognizing possible biases associated with gizzard analyses (Swanson and Bartonek 1970). No attempt was made to correct for additional possible biases resulting from where and when birds were collected. In this report, percent vegetation in gizzard of birds represents only natural food and does not include commercial grains which obviously came from baiting or feeding.

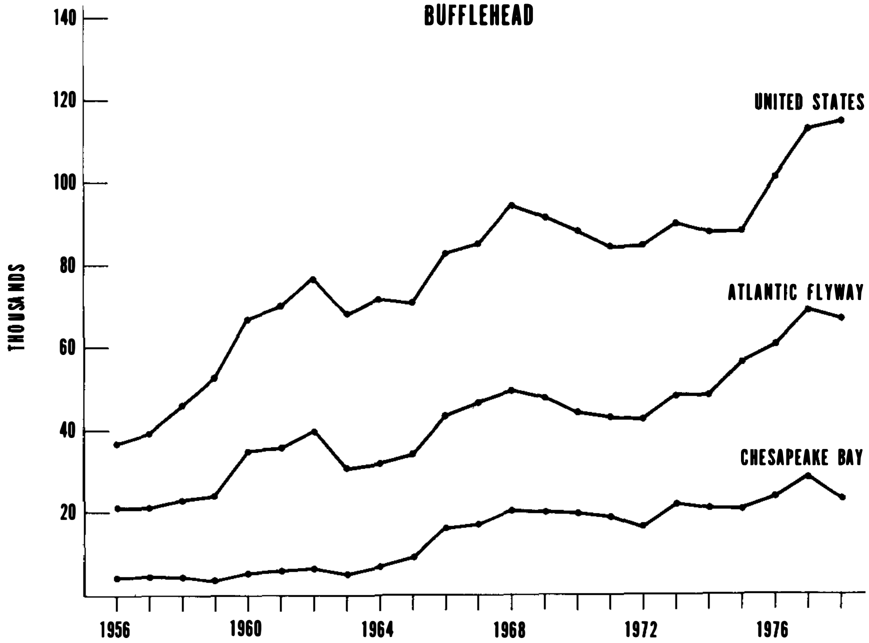
Results and Discussion

Survey data for the 25-year period (Tables 1 and 2, Figures 1 and 2) indicate that there has been a decline in the winter populations of canvasback (*Aythya valisineria*) ($P < 0.01$), goldeneye (*Bucephala clangula*) ($P < 0.05$), redhead (*Aythya americana*) ($P < 0.01$), and ruddy duck ($P < 0.01$) in Chesapeake Bay, while bufflehead (*Bucephala albeola*) populations in the Bay have increased ($P < 0.01$). Scaup and scoter populations in the Bay have not shown changes ($P > 0.05$) during this 25-year period. Changes in the United States populations of these seven species during this period were similar to changes in the Bay, except for canvasback and redhead which did not show changes ($P > 0.05$).

Population changes of these seven species for Chesapeake Bay during the 10-year period (1970-79) and the 5-year period (1975-79) were not significant ($P > 0.05$,

Table 1. Range and average populations of seven diving duck species in three areas during 1955-1979 as determined from aerial winter surveys.

Species	Area	High count	Year	Low count	Year	25 Yr. $\overline{X}$
Bufflehead	Chesapeake Bay	36,023	1977	2,502	1959	14,252
	Atlantic Flyway	72,138	1977	20,124	1957	42,311
	United States	123,039	1977	32,617	1957	78,741
Canvasback	Chesapeake Bay	234,325	1955	44,120	1958	88,655
	Atlantic Flyway	305,720	1955	88,113	1971	143,407
	United States	480,962	1955	179,321	1972	285,641
Goldeneye	Chesapeake Bay	40,518	1956	2,445	1976	19,591
	Atlantic Flyway	95,185	1963	36,395	1974	64,875
	United States	191,039	1966	109,118	1974	154,427
Redhead	Chesapeake Bay	118,800	1956	2,200	1975	32,536
	Atlantic Flyway	296,167	1966	38,982	1960	130,376
	United States	1,273,440	1956	246,160	1960	546,568
Ruddy duck	Chesapeake Bay	109,600	1955	4,703	1976	29,552
	Atlantic Flyway	156,108	1955	26,574	1968	64,418
	United States	265,533	1967	127,985	1978	203,528
Scaup	Chesapeake Bay	111,200	1968	5,570	1959	59,108
	Atlantic Flyway	938,369	1966	303,096	1976	591,218
	United States	2,797,334	1963	720,948	1978	1,563,968
Scoter	Chesapeake Bay	130,900	1971	1,940	1968	20,982
	Atlantic Flyway	207,900	1967	28,349	1975	74,940
	United States	395,114	1967	88,855	1956	166,734



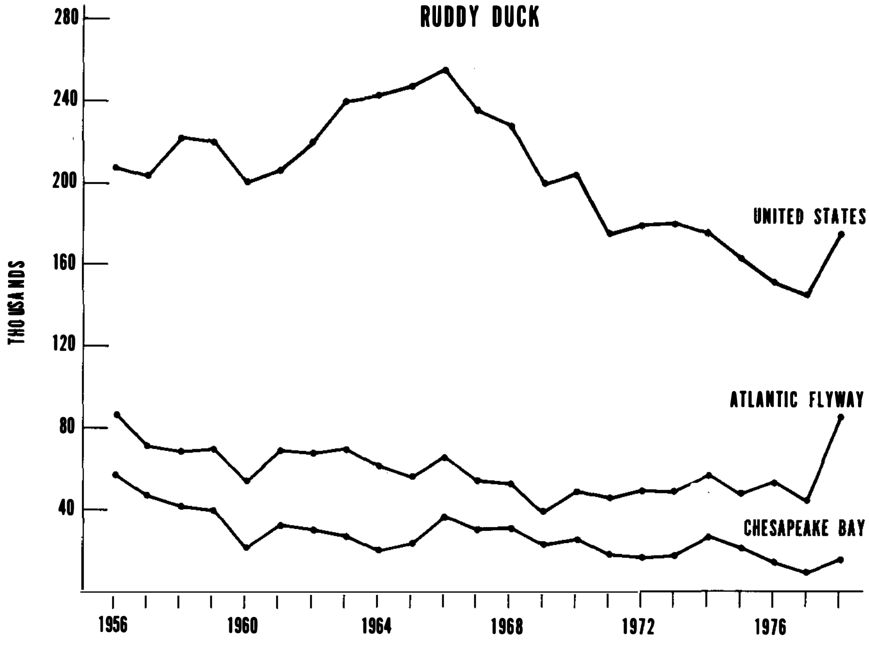
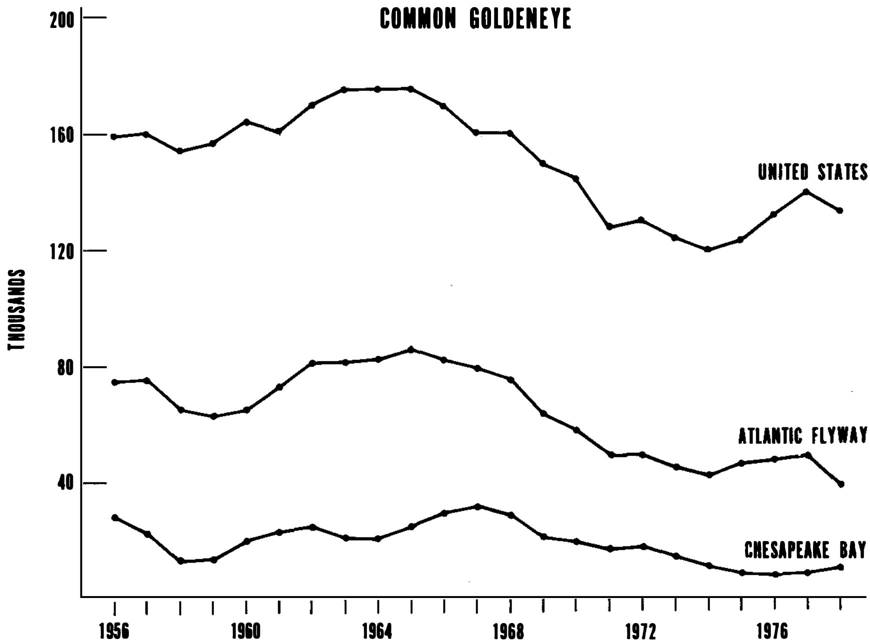
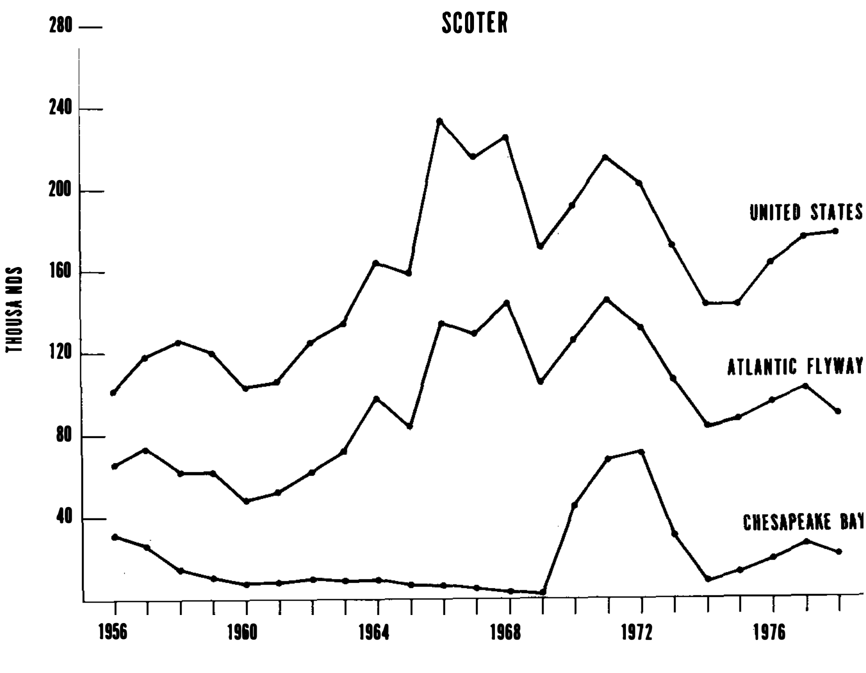


Figure 1. Population trends (3-year running average) of bufflehead, ruddy duck, common goldeneye, and scoter, 1955-1979.





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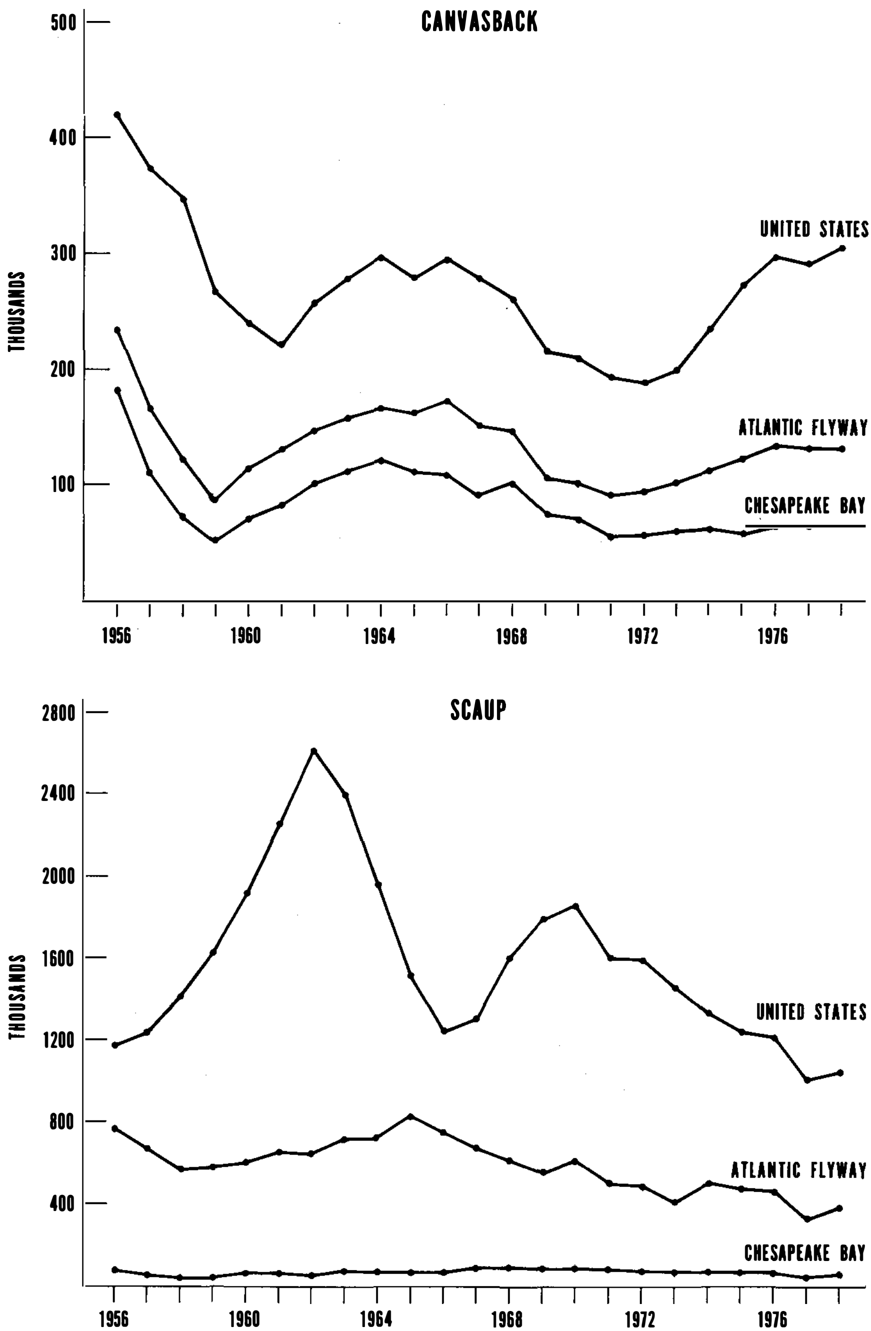

Figure 2. Population trends (3-year running average) of canvasback, scaup, and redhead, 1955-1979.

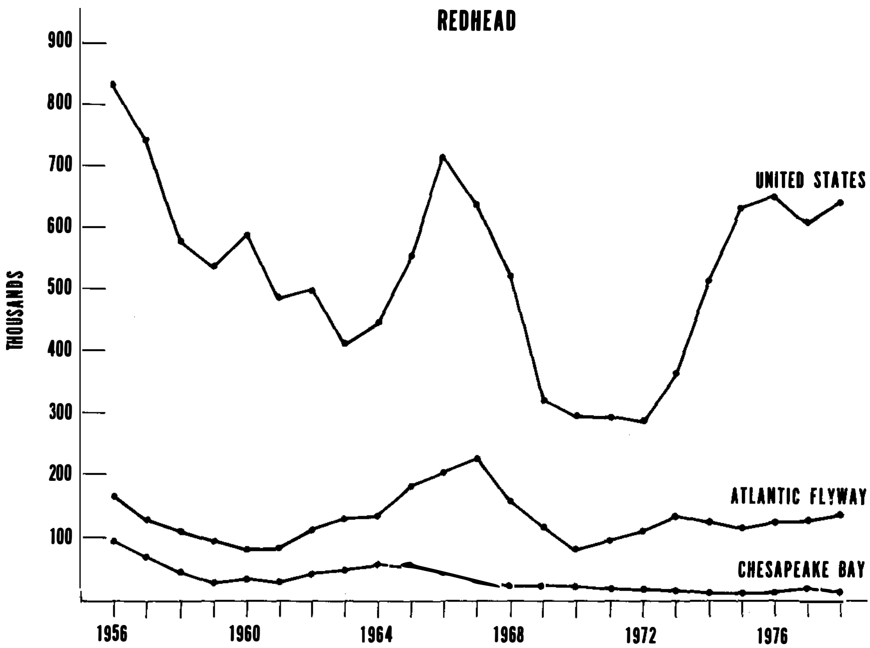

Figure 2. Continued

Table 2). Bufflehead populations during the 10-year period, however, increased ($P < 0.05$) in the Atlantic Flyway and the United States and canvasbacks increased in the Flyway and in the United States ($P < 0.01$). Increases in bufflehead numbers reflect recovery from overshooting early in the century (Erskine 1971). The United States redhead population increased ($P < 0.01$) during the 10-year period, whereas the United States scaup population declined ($P < 0.05$).

Results of food habits data from 1890-1979 indicate that bufflehead, goldeneye, and scaup populations have fed predominantly on mollusks and crustaceans, and to a lesser extent on vegetation (Munro and Perry 1981). During this 90-year period there has been a slight decline in the percentage of vegetation found in the gizzards of these birds (Figure 3). Similar changes in the food habits of scoter were noted, although these findings are based on a much smaller sample (Unpublished data, USFWS files). The distribution of these birds in the Bay during 1955-1979 has not changed drastically and therefore it appears that the distribution and abundance of these four species have not been greatly influenced by changes in the Bay environment.

Increases of the United States canvasback and redhead winter populations during the 1970s probably resulted from restrictive hunting regulations on these species and favorable breeding conditions. Similar population increases should have occurred in Chesapeake Bay if one assumes similar mortality factors throughout the United States for these species during this period. The fact that Chesapeake Bay populations of these two species did not increase at similar rates suggests that habitat changes on the wintering grounds may have been an important factor causing changes in the distribution of wintering populations.

During this same 10-year period, Chesapeake Bay experienced a precipitous decline in submerged aquatic vegetation, which canvasbacks and redheads have traditionally used as food (Stewart 1962). The canvasback is now feeding predominantly on clams (Perry and Uhler 1976), whereas the redhead is still feeding predominantly on vegetation (Figure 3). It is unknown why the redhead did not adjust its feeding habits to changing habitat conditions as did the closely related canvasback. Possible explanations, however, include anatomical differences in bill structure (Goodman and Fisher 1962) and gizzard musculature (Unpublished data, M. C. Perry).

Local distribution of the canvasback in the Bay did not change markedly during the early years of the surveys. Redhead populations now are most often found in areas of higher salinity (e.g., Tangier Sound, Va.) where eelgrass, *Zostera marina,* is the predominant species of submerged aquatic vegetation. Numerous historical accounts, however, indicated that freshwater areas like the Susquehanna Flats were very important to canvasbacks and redheads especially early in the winter (Bent 1923). These species were seldom recorded in freshwater areas of the Bay in recent years.

Recent population increases of canvasbacks and redheads have been observed in North Carolina and are believed to be a result of more abundant vegetation resources there. It is possible that human population increases in the Chesapeake

Table 2. Rate of population change (birds per year) for seven diving duck species during three time periods in three areas.

		Areas		
Species	Years	Chesapeake Bay	Atlantic Flyway	United States
Bufflehead	1955-79	+ 1,086**	+ 1,807	+ 2,814**
	1970-79	+ 957	+ 2,978*	+ 3,862*
	1975-79	+ 1,354	+ 2,881	+ 6,271
Canvasback	1955-79	− 3,271**	− 3,142*	− 4,068
	1970-79	+ 556	+ 6,053**	+16,967**
	1975-79	+ 3,256	+ 1,879	+10,871
Goldeneye	1955-79	− 613*	− 1,654**	− 1,806**
	1970-79	− 402	− 1,138	+ 870
	1975-79	+ 1,537	− 3,629	+ 2,005
Redhead	1955-79	− 2,995**	− 769	− 7,309
	1970-79	− 1,159	+ 4,164	+50,866**
	1975-79	+ 760	+ 2,705	+17,877
Ruddy duck	1955-79	− 1,719**	− 899	− 2,621*
	1970-79	− 632	+ 5,159	− 786
	1975-79	− 74	+17,669	+15,543
Scaup	1955-79	− 215	−15,371**	−18,465
	1970-79	− 5,896	−15,986	−62,798*
	1975-79	−11,568	−50,371	+16,516
Scoter	1955-79	+ 391	+ 1,133	+ 2,720
	1970-79	− 4,880	−10,246	− 9,108
	1975-79	+ 2,807	+ 4,127	+ 9,809

*Significant ($P < 0.05$)
**Significant ($P < 0.01$)

Bay area have resulted in a greater loss of preferred habitat for these species than in other less populated areas of the United States.

The ruddy duck fed extensively on vegetation in the past (Cottam 1939), but now, based on limited sampling, seems to be feeding predominantly on invertebrates (Figure 3). The significant decline in the ruddy duck population in the Bay, however, has paralleled the United States and Atlantic Flyway population changes indicating that these changes are a continental phenomenon. Ruddy ducks in Chesapeake Bay are increasing in numbers around cities like Baltimore and Washington, D.C. (Wilds 1979), where they are probably feeding on tubificid worms (Tubificidae). This has been observed in the Philadelphia area (Stark 1978).

Long-term food habits data for Chesapeake Bay diving ducks have shown a general decline in the diversity of estuarine food organisms consumed by the ducks. Five species of submerged aquatic vegetation and 22 species of invertebrates that were found in the 1890-1959 sample of diving ducks ($n=392$) were not found in the gizzards of the 1970-1979 sample ($n=504$). These plants and invertebrates were once found in the fresh or brackish tidal areas of Chesapeake Bay. One of these species, the isopod (*Chiridotea caeca*), is now classified as endangered in Virginia (Wass 1979).

Some species of invertebrates, however, have increased in distribution and abundance. The brackish-water clam (*Rangia cuneata*), first reported in the Bay by Pfitzenmeyer and Drobeck (1964), is now found throughout the Bay in low salinity (< 15 ppt) areas. This adventive clam was consumed by the canvasbacks,

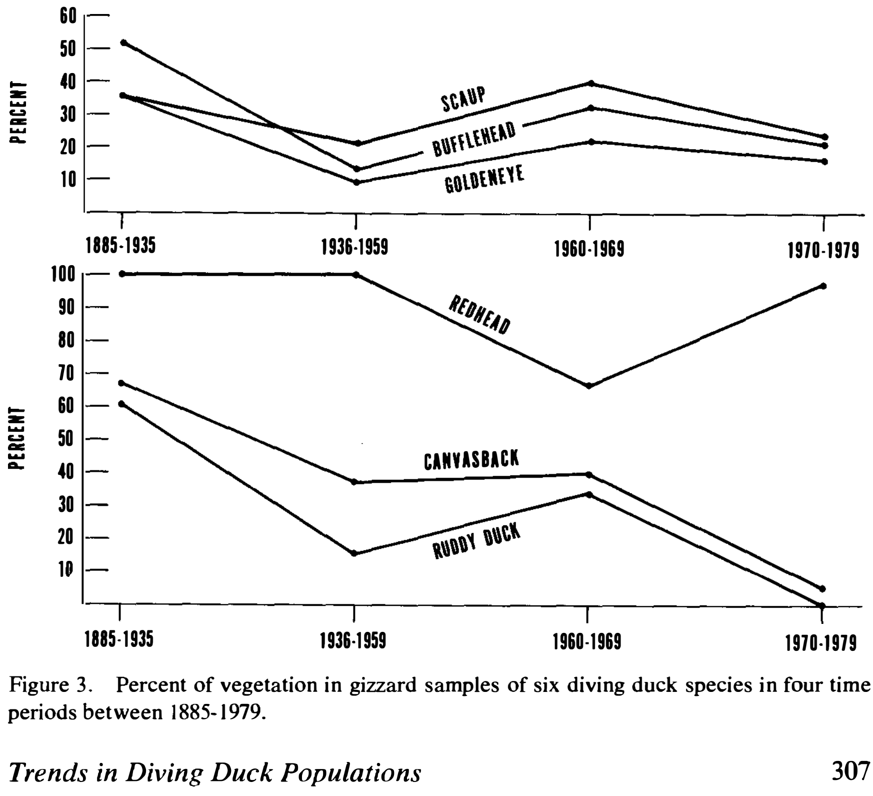

Figure 3. Percent of vegetation in gizzard samples of six diving duck species in four time periods between 1885-1979.

goldeneyes, redheads, and lesser and greater scaup during the 1960s and 1970s. The amphipod, *Leptocheirus plumulosus,* was also consumed by diving ducks during the 1960s and 1970s, but was not reported as a food item in birds before 1960. These two organisms, which seem to thrive in areas of low water quality, have provided additional food while other food sources more susceptible to environmental degradation have declined.

Eurasian watermilfoil (*Myriophyllum spicatum*) is another organism that increased its distribution and abundance during the 1960s (Bayley et al. 1978). This submerged aquatic plant, although not generally considered to be a preferred duck food compared to other aquatics (Martin and Uhler 1951), formed 2 percent of the food of diving ducks in the 1960s. The use of this plant may account for the slight increase of vegetation in the gizzards of diving ducks during this period (Figure 3). The decline in the percentage of vegetation used by redheads during the 1960s remains unexplained.

The exotic Asiatic freshwater clam (*Corbicula manilensis*) was first reported in the James River by Diaz (1974). *Corbicula* has since been found in the Potomac River (Dresler and Cory 1980) and in the Susquehanna Flats (Unpublished data, G. M. Haramis). *Corbicula* has been consumed by dabbling ducks in Chesapeake Bay (Perry and Uhler 1981) and by canvasbacks in California (Unpublished data, M. C. Perry), but has not been reported as a diving duck food item in Chesapeake Bay. *Corbicula* may become an important diving duck food item in freshwater areas of the Bay which are now practically devoid of submerged aquatic vegetation and invertebrates.

Conclusions

Total numbers of diving ducks wintering in Chesapeake Bay have declined during the period 1955-1979. The bufflehead is the only species that increased, while four species have significantly declined. In some species, similar changes have occurred with the Atlantic Flyway and the United States populations, indicating that the decline has been one of broad regional or continental magnitude and not a local phenomenon. These situations are believed to reflect the strong influence of breeding habitat conditions on recruitment. With canvasbacks and redheads, however, there are indications that local population changes are directly related to the changing winter habitat conditions of Chesapeake Bay.

Long-term food habits research has indicated that food resources for diving ducks in Chesapeake Bay have declined in distribution and abundance. The reduction of submerged aquatic vegetation has probably been the most important wintering habitat change affecting diving ducks, although the diversity of invertebrate food resources also seems to have declined. Diving duck species that fed predominantly on invertebrates seem to be little influenced by the loss of submerged aquatic vegetation. Other diving duck species that fed predominantly on submerged aquatic vegetation in the past have been most greatly affected and probably will continue to be affected if the low level of submerged aquatic vegetation persists.

Acknowledgements

Many people assisted in the collection of data, but of particular importance were R. Andrews, J. Goldsberry, and M. Smith (U.S. Fish and Wildlife Service), L. Hindman and V. Stotts (Maryland Dept. Natural Resources), and F. Settle (Virginia Game Comm.) for waterfowl survey data. C. Rawls and F. Uhler provided food habits data. E. Bell, C. Ellis, P. Longabucco, and P. Miller assisted with data tabulation and graphing. P. Geissler, E. Heinlein, L. Moyer, and B. Williams assisted with statistical analyses, and R. Coon, J. Nichols, and F. Percival reviewed drafts of this manuscript.

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A Concept of Management for the Chesapeake Bay

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To those who have spent any considerable period coping with the many factors that can combine to frustrate the aims of resource management, the very idea of managing the Chesapeake Bay—large, complex, and over-laid by competing uses and by diverse political mechanisms as it is—must seem a remote possibility.

Were it not for the positive happenings of the past decade, one would approach the subject of Bay management with great reservations. It is the purpose of this paper to outline recent events and to suggest a management strategy that may already be more nearly established than is generally recognized.

The facts, ideas, inferences, conclusions and projections that follow come from the many scientists, public officials, administrators, and representatives of the many publics who work on, use, and enjoy the Chesapeake Bay. Sincere thanks are due, and herewith given, to the numerous individuals from whom the ultimate hypothesis of this paper is drawn.

The Bay in Brief

It is roughly 180 miles (290 km) from tide's head on the Susquehanna to the mouth of the Chesapeake Bay at the Virginia Capes. The Bay's surface area is 4,300 square miles (11,137 km^2); only four states have more inland water. Its 8,000 miles (12,874 km) of shoreline exceed that of all but seven states. Five major rivers and some 150 smaller rivers and creeks empty into it. Its basin, drained by the Susquehanna, Potomac, Rappahannock, York, and James, is more than 64,000 square miles (165,760 km^2), about the size of Missouri. Its upper-most headwaters reach nearly to the Finger Lakes of New York to the north, and west to the spine of the Allegheny Mountains in West Virginia (Cronin 1980).

The territory of six states and the District of Columbia lie all or partly within its basin. Parts or all of 138 counties contribute their run-off to the Chesapeake. There were 8.2 million people in the Bay's tidewater region in 1974, by 1980 that had increased to about 9 million, and according to the Corps of Engineers (U.S. Army Corps of Engineers 1977), populations of 12.5 and 16.3 million should be expected by the years 2000 and 2020.

The Chesapeake population grew at the rate of 27 percent between 1960 and 1970, twice as fast as the national average for the period. Four great metropolitan centers, Baltimore, Washington, Richmond, and the Hampton Roads complex, make up the southern bulge of the great East Coast megalopolis, and, in effect, control the Bay's destiny.

The Bay has produced upwards of $175 million annually in seafood products, though reductions in quantity of recent years are masked by higher prices; recreational pursuits bring in more than $200 million and the Bay is known as one of the world's most heavily used recreational boating areas. Maryland alone registered 68,000 boats in 1970, and 132,000 in 1979 (Chesapeake Bay Consortium 1980). The land on both sides of the Bay is intensively used for both summer and year-round residences; farming and forestry are still major land-uses around those parts of the Bay not pre-empted by residential development. The number of Canada geese wintering in the Bay area consistently exceeds 400,000, it is a major wintering area for the continental whistling swan population, and several hundreds of thousands of ducks of many species winter, migrate through, or nest in Bay waters and marshes.

Hundreds of cargo vessels annually load and unload at the great ports of Baltimore and the Hampton Roads. Their cargo annually exceeds $8 billion in value for some 100 million tons of merchandise, largely bulk products such as coal and oil.

Competition in Bay Use

Such a vast array of both compatible and competing uses has given rise to anxieties about the future of the Bay, because these uses are seen as the actual or potential cause of evident declines in the productivity of the Bay resources. Public concerns manifest themselves in calls for "management;" yet the users are unwilling to be managed in any way that might place them in a disadvantageous position with respect to other competitiors, or place restrictions on their uses.

Surface congestion has intensified due to the rapid expansion of recreational boating and commercial freight traffic. Boaters ignore mandated sanitation devices when away from surveillance. More boats bring demands for more marinas that require more dredging and filling of the shoreline. Commercial fishermen contest with sport fishermen over shares of dwindling stocks of striped bass.

The really important issue, of course, is water quality. If the natural basis for the productivity of the Bay is maintained, through prudent water quality management, the dependent and collateral uses can be continued even though within a sharing system that allows more people to have somewhat less. However, deterioration in water quality will finally produce sterility, and destroy the Bay for most of the amenity and profitable uses that have made it one of nature's great and most productive ecosystems. True, the Bay would continue to have value for transport of commerce and wastes even though its ecological fundament is destroyed. *The essence of the challenge of management of the Bay is to establish and maintain a system that will make it possible to have both.*

Historical Perspectives of Cooperation

The first settlers in Maryland disembarked on St. Clements Island in the Potomac in 1634. One year later there was fighting between Virginians and Marylanders over the ownership of Kent Island. Lord Baltimore prevailed in that encounter, but it was an uneasy truce until the Compromise of 1657 brought a measure of stability. By 1785 the need to resolve boundary problems had become acute and the result was a Compact which stabilized realtionships between Maryland and Virginia until the oyster wars of the Potomac flared up early in this century. These were resolved by the Compact of 1958, establishing a bi-state commission for the division of the spoils from the Potomac's rich oyster beds and fin fisheries.

Meanwhile, in 1940, the states sharing the Potomac Basin had agreed to the formation of the Interstate Commission on the Potomac River Basin. Purely advisory, the Commission studied, recommended, and advised over the years, without establishing a workable framework for the induced or coerced control required to limit pollution entering the Potomac River. In 1970, its weaknesses evident, a new compact was negotiated that would have transfered to the Commission a measure of control over water uses. This Compact was rejected by both Pennsylvania and West Virginia, in fear of domination by alien interests (Eveleth 1979).

In that same year, however, the Susquehanna River Basin Compact established a Commission to guide water uses in the Basin of the Bay's largest contributor.

More recently, the states, the Federal Government, academic institutions and the public have shown an increasing interest in the future of the Bay. A landmark event was the 1977 Bi-state Conference on the Chesapeake Bay where high state officials made public promises of cooperation in Bay matters. A year later came the establishment of the Chesapeake Bay Legislative Advisory Commission by Maryland and Virginia; and just one year after that, the two states established the Bi-state Working Committee on the Chesapeake Bay as a means of coordinating related work across their common boundary in the Bay. In 1980, acting on the recommendations of the legislative advisory group, the two states created the Chesapeake Bay Commission to establish and sustain coordination and cooperation in Bay affairs.

In the academic world, the Chesapeake Research Consortium now provides coordination of the Chesapeake Bay research efforts of the Virginia Institute of Marine Science, The University of Maryland, the Johns Hopkins University, and the Smithsonian Institution.

Water quality and related parameters of Bay concerns are being addressed by a special study of the Chesapeake Bay being carried out by the Environmental Protection Agency. Now in the last stages of its authorized five year program, the study has concentrated on toxic substances, submerged aquatic vegetation, and eutrophication.

Recently, the National Science Foundation agreed to finance the development of the Chesapeake Bay Information Center to provide a central location for the collection and distribution of information about the Bay.

The Chesapeake Bay Research Coordination Act of 1980 (P.L. 96-460) was enacted by the 96th Congress to provide direction and coordination for the federal research efforts on the Bay.

Growth in Public Interest

Concurrently with the expansion of official state activities on the Bay, there has been a remarkable eruption of public interest in Bay affairs. The Chesapeake Bay Foundation, established in 1966, has continued to grow in strength and scope and now supports a broad program of environmental education from one end of the Bay to the other. Ten years ago, the Citizen's Program for the Chesapeake Bay was started as a means of bringing together organizations with Bay interests to discuss and rationalize approaches to the solution of Bay user conflicts. It is responsible for the administration of participation programs for the Environmental Protection Agency, the National Science Foundation, and the Virginia Environmental Endowment.

In Maryland, the Coastal Resources Advisory Committee, organized under the aegis of the Maryland Tidewater Administration, and the Maryland State Water Quality Advisory Committee have been active in promoting both agency awareness and public involvement in decisions that affect the Chesapeake. Additionally, the advisory groups for the Clean Water Act Section 208 planning function, the Coastal Zone Management Act Section 309 Advisory Committee, and, of course, many local, regional, and national organizations have adopted review and action on Bay affairs as parts of their programs.

The cumulative effect of heightened citizen awareness of the Bay as a major renewable resource has been of inestimable value in stimulating and sustaining Bay programs.

Management Considerations

Finally, we come to the question of whether in fact the Bay can be managed. If management can be defined in terms of Bay resources, how can it be established? Webster is of little value in suggesting an appropriate definition of management, but its essential concept can be fairly simply stated as: "*the taking of actions calculated to result in the achievement of a predetermined goal.*" Even when applied to simple situations, this definition still leaves very significant problems: How does one establish goals that have a reasonable expectation of achievement? That question is difficult for the individual, given the absence of useful data on which most personal decisions are made. By comparison, the problems of establishing societal goals in a complex of the size and scope of the Chesapeake Bay are staggering. Assuming that the goals have been established what kind of action must be taken? Who will take it? And finally, "Who decides?"

With the unusually well developed public interest in the Bay, reflected as it is in official actions by the two states directly involved in and benefiting from the Chesapeake, it would appear that the establishment of a broad and comprehensive management regime may be anticipated. That is not the case. Powerful political philosophies alone would prevent the adoption of a unified management scheme. The most obvious of these is that of independent sovereignty. There is not only an apprehension of loss of sovereignty from state to state, as reflected in the failure of the Potomac River Compact; the same phenomenon appears even more strongly in state and local rejection of any federal government involvement in Bay management. Local officials have similar concerns about state domination. Considering the fact that most land and adjacent water-use decisions are largely in the hands of county officials, the latter may well be considered the ultimate controllers of the destiny of the Bay (Reiger 1978).

The intricate and extended web of jurisdictions that affect the Bay are, of course, influenced to a large degree by economic factors. But along with these, of which the domination of Maryland by the Port of Baltimore is most apparent, the attenuated geography of the Bay itself is a powerful deterrent to the acceptance of outside direction. It is difficult for business interests in the Hampton Roads area to see Baltimore as other than a powerful economic competitor. Add to this concept the disorientation that comes from the physical distance from the upper to the lower end of the Bay, and it is apparent why there have been problems in establishing a truly cooperative and understanding relationship. As one ventures into many of the lesser regional centers and smaller towns about the Bay the feeling of physical and cultural isolation takes on tangible dimensions. The independent spirits that dwell in the water-dependent families of the Bay are appealing to the readers of the popular bay literature, but they are a long way from accepting the regimentation that might come from the institution of a formal management system.

The inherent difficulty of substituting broad social goals for the goals of the individual or a class of individuals deriving their livelihood from a common resource has been well described (Hardin 1978). There are classic examples of the "tragedy of the commons" syndrome scattered throughout the Bay's cosmos. In dealing with oyster production, the waterman can be expected to do that which furthers his self interest: to take that extra measure of harvest from the "common" grounds. His individual actions, isolated and alone, would mean nothing to the future of the Bay. But the action of the individual when multiplied by all those so motivated means over-exploitation that leads to economic destruction of the resource.

In the face of all these human and institutional problems, what basis is there for any optimism that the Bay can be managed?

Bay Management Redefined

It must be accepted that the classic definition of the term "management," applied to all Bay uses in a comprehensive way with centralized direction, would be impossible to attain or, for that matter, to organize effectively. Moreover there is no real urgency to establish such a system. Existing mechanisms that deal with the uses of the Bay, if not entirely adequate are in place and functioning. The Chesapeake Bay Commission is a potent force for leadership and coordination in resource matters. Under the Commission's charter (approved October 3, 1980) all needed regulation of Bay uses will come directly from the existing governmental authorities. This conclusion was the recommended choice of the seven options considered by the Chesapeake Bay Legislative Advisory Commission. The others were: (b) a bi-state commission without federal participation, (c) a federal-interstate commission, (d) a Title II Commission under the Water Resources Planning Act of 1965, (e) a Commission or agency established under Section 309 of the Coastal Zone Management Act of 1972, (f) a planning agency under the authority of Section 208 of the Water Pollution Control Amendments, and lastly, (g) a federal regional management authority (Gartlan and Cronin 1980).

As promising as the Chesapeake Bay Commission appears to be, and by any standard it must be considered a quantum leap away from the provincialism that reigned but a few years ago, it nevertheless has several apparent weaknesses. The first is not that it has no executive powers; rather, its principal weakness is the separation of the Commission from the local jurisdictions and the interested and concerned public.

If resource managers have learned anything in the past decade it is that without the forceful backing of an involved public and the support of local officials, progress is certainly going to be slow if it is made at all. That kind of involvement and support, however, does not come cheaply. It is bought with an earnest willingness on the part of legislators and agency officials to seek advice and to listen responsibly when that advice is given.

The commission's charter shuns association with the Federal Government, a protection that will make it difficult to engage the knowledgeable federal agencies in cooperative endeavors, of which there are bound to be many of real importance.

Finally, the Commission is not to involve the other states in the Chesapeake's drainage basin nor the District of Columbia. One could not advocate the entrance of these other potentially important partners in the day to day management decisions that will have to be made for many of the direct uses of the Bay. At the same time, however, these other states and the District must be made aware continually of the importance of their decisions and actions in relation to the welfare of the Bay, and conversely the contribution the Bay makes to their welfare, both directly and indirectly (Mathias 1978).

Public Understanding of Water Quality

The primacy of water quality in Bay management has been identified as a fundamental consideration. Yet no aspect of Bay management is apt to be as difficult to describe and articulate. It is in this context that the suggestion of a "segmented approach" as described by DeMoss (DeMoss et al. 1981) toward water quality management in the Bay has such an appeal. The average individual or jurisdiction has no reference points against which he can compare the condition of that part of the Bay in which he operates. For that matter, even the manager with abundant data would be hard pressed to make useful decisions unless he had the ability, through a data integration and reconciliation system, to relate water quality in one part of the Bay to other parts and the total. The segment concept, with its innate management orientation, is essential to a Baywide water quality system.

There are two other essentials for a Bay water quality management effort. The first is a continuing scientific collection and review of data, examination of criteria, and standards updating, supervised by a broadly-based scientific unit (Alexander 1980). Water quality cannot be protected in the absence of the impartiality of sound science. Science must provide the foundation for decisions. The scientific unit must be flexible to the extent that it can convene and disband panels of experts to work on various parts of the multi-faceted problems that will inevitably have to be faced in any Bay-wide water quality management program.

The second essential is an advisory group, broadly based across both public interest and local jurisdictions, to assist in the difficult tasks of understanding resource needs, setting water quality goals, and establishing priorities for action.

A Functional Concept of Bay Management

Despite its complex character, there are in and around the Bay today all the essential elements for a functional water quality management system. There is the Chesapeake Bay Commission that can and should provide the direction and essential state governmental support for the water management structure. There is a sound conceptual model—the segmented approach. There is a scientific capability in place in the research establishments on the Bay, coordinated by the Chesapeake Research Consortium and the anticipated Federal Chesapeake Bay Research Coordination Office. Public involvement in water quality matters can become the function of the many citizen organizations with a strong commitment to Bay affairs, and with relative ease. The only component that would have to be expressly created would be an appropriate public participation body built upon the foundations of the existing advisory boards and representing the public and the local constituencies.

Regional meetings of the advisory groups from the "segmented" areas of the Bay would provide the core of citizen involvement. An annual meeting would provide a means of bringing the various regional groups together to discuss the status and needs of the Bay as a whole, and to establish standards for the Bay which would in turn determine the requirements for each part of the Bay. These groups would be working in an advisory capacity and would have no direct management responsibilities. By participation in the development of recommendations for standards of water quality they could be expected, in time, to recognize and support the need for adherence to the accepted quality standards and would thus constitute an essential part of the total management structure.

The agency that will have the key role in fostering a Bay water quality management system is the Chesapeake Bay Commission. It can be the integrating element that brings together the scientists, the citizens, the local officials, and last but not least, the officials of the respective management agencies, initially in Maryland and Virginia, but ultimately in a cooperative framework with the river basin commissions, the other states, and the Federal Government. By going about its business in the same spirit of cooperation that led to its creation, by leading and guiding, by stimulating essential research and education, by involving those who must be "managed," the Commission can live up to its destiny, and manage the Bay!

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Improved Management of the Chesapeake Bay: Closing Comments

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In response to an invitation, from the Program Committee Chairman, for the Maryland Chapter of the Wildlife Society to offer suggestions for this 1981 conference, we developed an idea to present to you a look at the Chesapeake Bay from the past and into the future. Our idea was for this session to serve as a window through which the rest of the nation could view their resources future if urbanization occurs there as it has in this area over the last 20 years.

I believe Eugene Cronin did an excellent job selecting the professionals to present this information to this session. After what I have seen and heard this afternoon, I believe we accomplished our goal. I suggest to those of you from other parts of our great nation, if this information does serve as a window to your future, it is time to do something. If this information serves not as a window, but is instead a mirror, then it is time to do something. We are the guardians of our national resources, and these resources are for all to enjoy and use. The wise use of these resources will come only through our voice being heard by our policy makers. Be not disturbed by looking through the window or into the mirror we presented for you, be motivated.

I wish you would join me in expressing our appreciation to the people for their time and work in preparing and presenting this session to you.

Strengthening Management of Public Lands

Chairman:
JOHN W. MUMMA
Director of Wildlife Management
Intermountain Region
U.S. Forest Service
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Cochairman:
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Caribou and Domestic Reindeer Grazing on Public Lands in Alaska: Introduction to a Unique Management Problem

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In northwestern Alaska the Bureau of Land Management (BLM) is attempting to cope with a unique grazing situation in which two populations of the same species, one wild (caribou) and one domestic (reindeer), compete for use of high-quality winter range. The problem of allocating range resources to wild and domestic grazers is not new to public land managers. For conventional livestock such as cattle, sheep, or horses, the manager can use knowledge of food habits and habitat needs of both the livestock and the wild ungulates as well as the forage available to accommodate both uses. He can monitor range trend and condition to maintain both the wild and domestic grazers within range capacity. However, because of the intraspecific nature of conflicts between domestic reindeer and wild caribou, management problems extend beyond mere allocation of range resources.

The need to address this problem has arisen because of the interest of the NANA Regional Native Corporation in intensifying reindeer grazing on BLM's Hadley reindeer allotment, on the Arctic Circle, which NANA now is permitted to use. The eastern half of the Hadley allotment is temporarily withdrawn from winter grazing of reindeer because caribou use that area. NANA's planned development of its reindeer operation depends on the use of the productive tundra winter ranges in that portion of the allotment. BLM land managers must make a decision on whether to allow winter reindeer grazing or to adjust the Hadley allotment boundary so as to permanently remove that area from future reindeer use and dedicate it to management as caribou winter range.

The decision made by BLM on this matter may have far-reaching effects on future land use decisions concerning reindeer grazing on all public lands in northwestern Alaska. Land status in Alaska is presently in a state of flux because of the Alaska Statehood Act of 1958 (Public Law 85-508), the Alaska Native Claims

Settlement Act of 1971 (Public Law 92-203), and the Alaska National Interest Lands Conservation Act of 1980 (Public Law 96-487). Prior to the last two laws, BLM managed most the land in northwestern Alaska that was grazed by reindeer. Now on much of this land, management authority is being transferred to other federal agencies, such as the National Park Service and the U.S. Fish and Wildlife Service, and land ownership is passing to the State of Alaska, as well as Alaskan Natives at the individual and village or regional corporation levels. To further complicate the situation, it is presently planned to manage reindeer grazing on public lands within traditional allotment boundaries by cooperative agreement of all state and federal agencies concerned. Any decision by BLM on the present Hadley allotment conflict is sure to affect reindeer management on all areas used now or in the future, regardless of land management authority, and will set a precedent regarding expansion of reindeer grazing onto caribou range.

Conflicts Between Caribou and Domestic Reindeer

The problems peculiar to caribou management and reindeer husbandry on overlapping ranges have been discussed by Klein (in press). The factor unique to this situation is that reindeer often are absorbed into migrating caribou herds. This has occurred frequently in Alaska where loose herding of reindeer is common, and it happens occasionally even where reindeer are closely herded, as in the Soviet Union. In Alaskan history, reindeer herding was widely successful only when major caribou herds in northwestern Alaska had declined and withdrawn from areas used by reindeer (Stern et al. 1977). When the caribou herd recovered and resumed its traditional migrations, reindeer were lost to caribou wherever ranges overlapped (Figure 1), and the reindeer industry receded to the Seward Peninsula.

Other important conflicts discussed by Klein (in press) are similar to those in conventional livestock operations in the western United States, but are accentuated by the intraspecific nature of caribou and reindeer grazing. When reindeer are loosely herded, the potential for competition for forage is increased because the dietary overlap with caribou is almost complete. If closely herded, reindeer use some areas more intensely and the potential for overgrazing increases (Andreev 1975). On slow-growing lichen ranges, where most of the potential for nutrient cycling is locked up in a cold, wet, organic mat, overgrazed areas recover slowly (Palmer and Rouse 1945). Because of limited range research, especially in recent years, on Alaskan tundra ranges and the limited or questionable applicability of research done elsewhere, any decision to increase reindeer use of these ranges should be made cautiously and conservatively.

Disease transmission is also important because of the intraspecific nature of caribou/reindeer grazing. If diseases such as brucellosis are to be controlled within the domestic reindeer herds, contact with caribou must be minimized.

Another major concern of reindeer owners is the losses from wolves (*Canis lupus*) that follow migrating caribou into reindeer ranges. Wolves not only prey on reindeer but can also scatter the herds.

The combination of all these factors makes coexistence of reindeer and caribou on overlapping ranges a complex problem for public land managers. Interest in expanding an existing reindeer herd on the BLM's Hadley grazing allotment into winter range that is important to the Western Arctic Caribou Herd (WACH) has focused statewide attention on these problems and BLM's ultimate solution. The histories of the WACH and the reindeer industry in this area illustrate the importance of any decision on these conflicting land uses.

History of the Western Arctic Caribou Herd

Through its history the WACH has had major changes in numbers, movement patterns, and distribution encompassing much of northwestern Alaska (Skoog 1968). When white explorers first visited the Seward Peninsula, in the late 1700s, caribou were seasonally abundant in the area (Van Stone 1959). Apparently, the caribou population decreased in the area in the late 1800s. By 1880, few caribou were left on the Seward Peninsula, and by 1890 the herd had contracted into its "center of habitation" in the central Brooks Range (Skoog 1968). This change probably was part of a natural fluctuation in population size.

Caribou continued to be virtually absent from most of northwestern Alaska until the mid-1930s, when caribou concentrations were located along the Chukchi Sea coast, north of the Seward Peninsula (Rood 1942). From 1950 onward, large portions of the WACH, often most of the herd, wintered south of the Brooks Range (Hemming 1971). Large concentrations of caribou have wintered in the tundra ranges of the Selawik Hills, Selawik Flats, and the Buckland River Valley (Figure 2). Since 1950, the WACH has used this area more consistently than any other portion of its winter range (Skoog 1968, Davis and Valkenburg 1978, Unpublished data from Alaska Department of Fish and Game 1979, 1980).

The WACH declined drastically between 1970 and 1976, when it dropped from 240,000 to only 70,000 animals (Davis and Valkenburg 1978). The decline was caused largely by excessive harvest (Davis and Valkenburg 1978) although natural predation, disease, and possibly, range conditions also contributed. It created a "caribou crisis" (Stern et al. 1977) in northwestern Alaska since a subsistence mainstay for the widely scattered human population of the region was suddenly in short supply. At the end of the 19th century, nomadic ancestors of local residents had coped with a similar situation by emigrating from the area, but that option was not feasible for people living in villages in modern Alaska. Fortunately, Alaska Department of Fish and Game (ADFG) placed restrictions upon hunter take and initiated a campaign to minimize waste of wildlife resources. The herd had several years of good reproduction that turned it toward recovery. Today, the best estimates of herd size are about 140,000 caribou (Patrick Valkenburg, ADFG, pers. comm.). The history of this herd shows, however, that any perturbation of the caribou population's well-being significantly affects the lifestyles of Alaskans in the 100,000 square miles (250,000 km^2) of northwestern Alaska that it ranges over.

History of Domestic Reindeer Grazing

Historical development of the reindeer industry in Alaska has been summarized by Stern et al. (1977). The reindeer industry has gone through three major phases of development. These are introduction and growth from 1891 to 1914, non-Native ownership and exploitation to 1937, and Native ownership and attempts to develop a self-sustaining Native enterprise since 1937.

Domestic reindeer from Siberia were introduced to the Seward Peninsula in 1891, when caribou were absent. Rev. Sheldon Jackson, General Agent for Education in Alaska, began the import of reindeer to supply a stable food source and promote industrial education for local Natives (Ray 1965). Reindeer continued to be imported until 1902 when the Russian czar forbade further export of reindeer from Siberia. By this time, more than 5,000 reindeer were in Alaska, from both importation and natural increase.

Despite its intended purpose, the reindeer industry benefited the Eskimos little during its early years. Most of the animals were given to Lapp herders, who had been brought to Alaska to help teach herding methods to local inhabitants, as payment for their services. Religious missions owned other herds. An investigation in 1906 by the Department of the Interior into the reindeer industry determined that it had not fulfilled its purpose, and Jackson was forced to resign. Department policy was changed to encourage placing more reindeer into Eskimo ownership (Ray 1975). By this time, the gold mining boom on the Seward Peninsula, which had provided most of the market for reindeer meat, had subsided and the easily accessible coastal ranges were showing effects of overgrazing (Lantis 1950).

After the collapse of local markets, white businessmen acquired ownership of most herds. By 1920, they expanded the reindeer industry into much of northwestern Alaska (Figure 1) and reindeer numbered about 180,000 in Alaska. From 1920 through 1929 the industry exported large amounts of reindeer meat to the continental United States. This market folded with the arrival of the Great Depression and when local demand also fell, large-scale reindeer operations collapsed.

Although the operations failed, the reindeer herds in Alaska grew to over 600,000 animals by 1934. It was apparent that these numbers were excessive. Range deterioration was widespread and many reindeer were lost to disease, predators, and winter starvation (Olson 1969).

In 1937, Congress passed the Reindeer Grazing Act (Public Law 75-413) in an attempt to restructure and save the industry as well as to save white owners from bankruptcy. The Act restricted ownership of reindeer in Alaska to Alaskan Natives and provided for the purchase by the Federal Government of all non-Native equity in the industry. During the first years that the Act was in effect, reindeer numbers declined, as the after-effects of the irruption seen in the 1920s and 1930s continued to influence the herds. At this time, many herders abandoned their herds and reindeer wandered away to join caribou herds or establish feral herds.

From the 1940s to the mid-1970s the reindeer industry consisted of small, family-owned operations primarily on the Seward Peninsula (Figure 1). Until recently, reindeer herding has been conducted partially for subsistence and partially for cash income. Free-use grazing permits issued by BLM on huge allotments, averaging almost one million acres (400,000 ha), and low stocking rates allow the herders great latitude in moving and grazing their animals. In most cases, reindeer are allowed to graze freely but are rounded up to be moved from summer range to winter range and back again. Animals are essentially wild and are harvested in the field, primarily in the fall. Meat and hides are used by the owner, used to pay herders or labor during slaughtering operations, or are sold in local villages.

The free-use permits issued by BLM for reindeer grazing are quite different from conventional grazing permits in the western United States. First, only Natives are allowed to own reindeer or apply for reindeer grazing permits in Alaska (U.S. Government 1979a). No grazing fees are assessed and no base property is required as in the West for conventional livestock grazing permits (U.S. Government

1979b). Natives need only own reindeer or be able to obtain reindeer in order to apply.

The creation of Native corporations under the Alaska Native Claims Settlement Act brought a new influence to the reindeer industry. For the first time, Alaskan

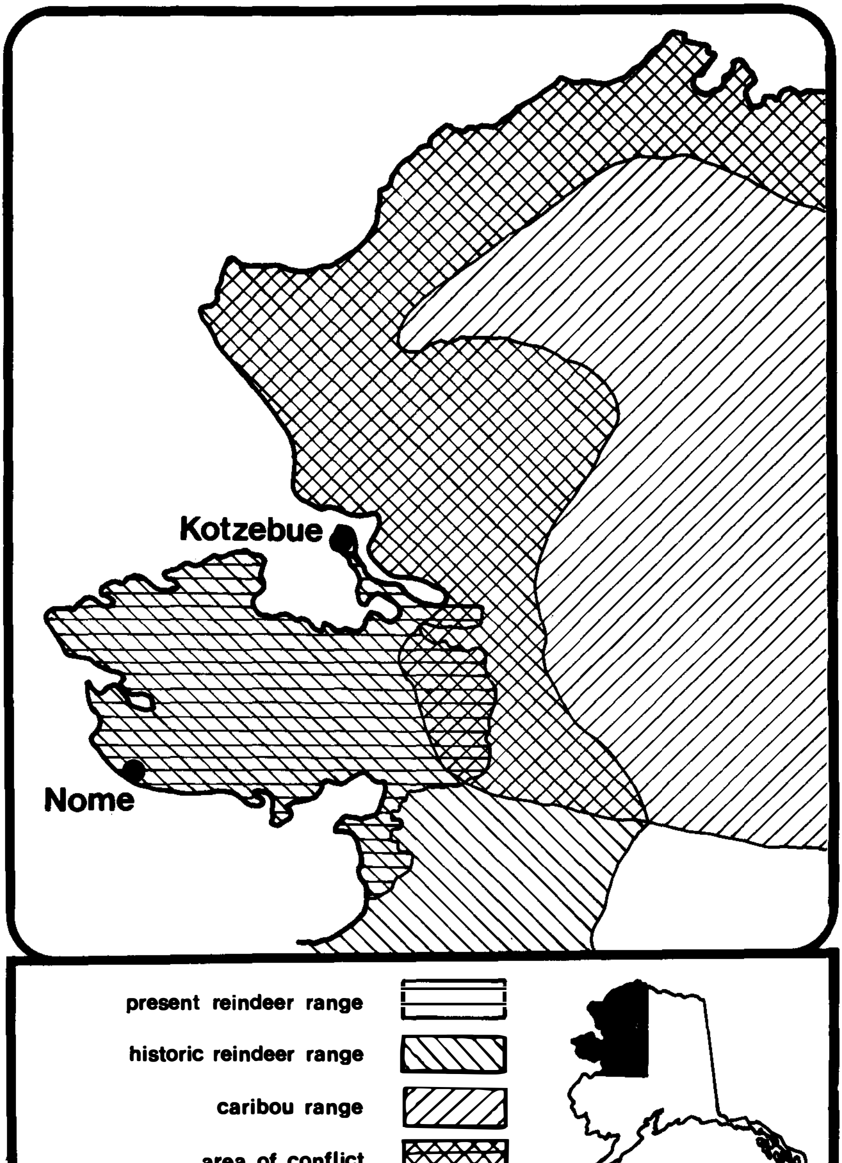

Figure 1. Present and historic distribution of caribou and reindeer in northwestern Alaska.

Natives had access to corporate resources that could be used to finance reindeer herding on public land. One entity in particular, the NANA Regional Native Corporation of Kotzebue, Alaska, has elected to invest in the reindeer business. NANA is leading a return of regional and statewide interest in reindeer as a northern-adapted, domesticated animal that can provide employment, income, and red meat for rural Alaskans. Marketable products are red meat for local, regional, and national markets, and velvet antlers for medicinal uses in potentially lucrative markets of the Orient. Hides are used locally and may find a wider market in the future.

The Oriental market for velvet antlers has the potential to bring large profits to reindeer owners. Prices soared from $1 per pound ($2.20 per kg) in 1969 to $40 per pound ($88 per kg) in 1979 (Arobio 1981). The market has since stagnated due to economic instability in South Korea, the major market, and increased supply from other sources such as red deer (*Cervus elaphus*) antler from Australia and New Zealand. This market may again be important in the future.

New interest in the industry has caused some changes in herding practices and goals, which in turn intensify potential conflicts with caribou. NANA now is permitted to graze reindeer on four BLM allotments, totaling 4.2 million acres (1.7 million ha), including the Hadley allotment. The Corporation wants to expand and intensify reindeer grazing on these lands. NANA's activities are unusual for the reindeer industry, in the amounts of money invested and in the vigor with which it is pursuing new goals for the industry.

Development of the Hadley Allotment Conflict

When caribou were absent from the region, the Buckland River Valley supported reindeer herding, including a large export-oriented operation of the Alaska Livestock and Packing Company in the 1930s (Stern et al. 1977). In 1953, after the industry failed and subsequently was reorganized, Paul Hadley, of Buckland, Alaska, began herding reindeer in the area. In 1962, BLM began issuing grazing permits, and granted Mr. Hadley a permit to herd 2,000 reindeer on the 2.2 million acres (890,000 ha) of range in the grazing allotment (Figure 2). To maintain his herd, Mr. Hadley and his family often had to restrict their reindeer to the western portion of the area or move their animals away from concentrations of caribou that ranged east of the village of Buckland. While this was not impossible, it could only be done because the number of reindeer kept on the area was small. During this time, reindeer on ranges north of the Seward Peninsula were lost to migrating caribou and several herders were put out of business.

In 1976, NANA acquired reindeer and grazing permits for areas adjacent to the Hadley allotment on the north and west. Interested in a more intensive and organized grazing program, NANA began to assess the reindeer grazing potential of tundra ranges on its allotments and adjacent ones. Accordingly, NANA contracted in 1976 with the Soil Conservation Service (SCS) to conduct range inventories and estimate the numbers of reindeer each allotment could support.

Using computer-aided analysis of satellite imagery, the SCS range scientists mapped 4.5 million acres (1.8 million ha) of tundra ranges in the summer of 1976 and produced a map of cover types in 1977. Associated with this map were estimates of potential reindeer stocking rates for the various allotments covered by the survey. These figures were based on extent of potential winter range, arbitrarily defined as areas covered with more than 15 percent lichen, an important winter forage of caribou or reindeer. The extent of these potential winter ranges was determined with little regard to snow conditions on the area which greatly affect forage availability for reindeer or caribou (Thing 1977, Skogland 1978, LaPerriere and Lent 1977, Pruitt 1959). Available forage by vegetation type on these areas was determined from 70 ten-plot transects on the 4.5 million acres (1.8 million ha) where data on annual production of vascular plants and nondecayed

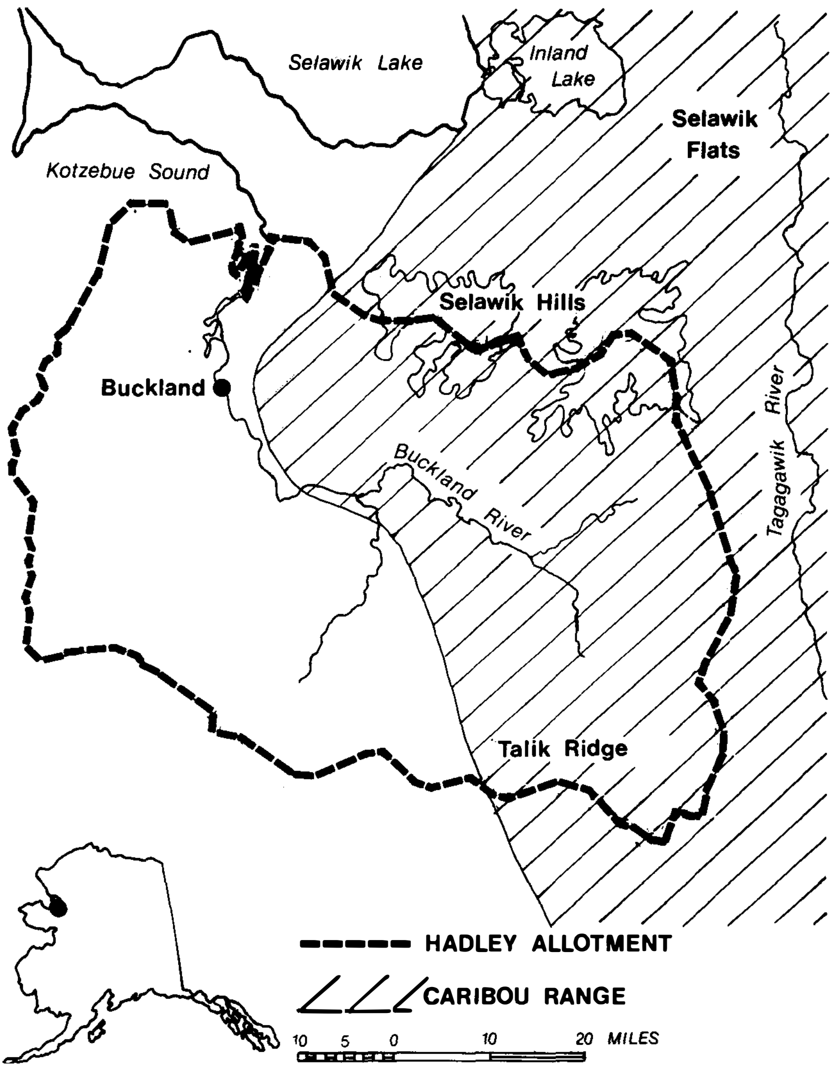

Figure 2. Location of Hadley reindeer grazing allotment and caribou winter range in the Buckland River area of northwestern Alaska.

standing crop of lichen were collected. Potential stocking rates were determined using this information, with a theoretical 5-year rotation requiring close herding of reindeer and assumptions that optimal use of lichens would be made (Andreev 1954). On the 2.2 million acre (890,000 ha) Hadley allotment, only 1.6 million acres (640,000 ha) were included on the classified satellite image used for cover mapping. In order to determine potential stocking rates on this allotment, habitat and forage composition data from the inventoried area were extrapolated across the 600,000 acre (250,000 ha) unmapped area.

From this broad inventory, SCS range scientists estimated that with careful grazing management, 33,285 reindeer could be supported on the Hadley allotment. No allowance was made for forage use by caribou on the area.

NANA has since taken over management of the Hadley reindeer operation and in 1981 received formal assignment of the Hadley grazing allotment. The Corporation proposes to expand its reindeer herd, based on use of the lichen-rich winter ranges in the Buckland River Valley and questionable stocking rates arrived at by SCS.

In 1979, NANA was given a permit by BLM to use the 800,000 acres (320,000 ha) in the Upper Koyuk River Basin, in addition to the 2.4 million acres (970,000 ha) that was already permitted to them, to allow for growth of their reindeer herds while BLM biologists assess the impacts that reindeer grazing would have on the one million acres (400,000 ha) of the Hadley allotment presently withdrawn from winter reindeer grazing. NANA owns 8,000 reindeer and is permitted by BLM to graze 13,000 animals on the 3.2 million acres (1.3 million ha) included in the grazing allotments it is allowed to use.

Meanwhile ADFG and BLM biologists have reported that large concentrations of caribou continue to winter in the eastern section of the Hadley allotment. In late February 1980, up to 15,000 caribou were located there and similar numbers were observed early in the winter of 1980-81. As many as 30,000 animals, approximately one quarter of the WACH, have been reported in this area in recent years (Patrick Valkenburg, ADFG, pers. comm.).

The apparently high quality winter range of the eastern half of the Hadley allotment has forced BLM to weigh alternatives about future use of this area. The area is crucial both to NANA's planned development of the commercial reindeer industry and as winter range for the WACH. The values of each use to the region and the potential economic effects of expanding reindeer grazing into caribou winter range must be assessed before necessary decisions can be made.

Socioeconomic Values

In making decisions concerning reindeer grazing on caribou range, public land managers must consider not only the obvious ecological conflicts but also the socioeconomic values and related impacts of both caribou and reindeer. Ultimate decisions may have wide ranging effects on the lifestyles of residents in all of northwestern Alaska.

Reindeer are privately owned and can serve as a source of income to the herder. Development of the velvet antler market, although unstable now, may bring large profits in the future. Because the herd in question here belongs to NANA, the regional Native corporation, profits from the reindeer operation would be distributed as dividend payments and services to Native residents in the Corporation's region. Reindeer might also be a stable source of red meat that could be sold to local village residents and the residents of Nome and Kotzebue. This has been a strong incentive for the expansion of the reindeer industry in northwestern Alaska. If the close herding necessary for careful rotational grazing and the projected commercial industry expansion is adopted, local herders would be employed and their salaries would bring money to the local economy. Development of meat-handling facilities and potential export markets for both meat and other by-products, such as velvet antlers and hides, could bring further economic benefits to the area.

On the other hand, caribou continue to be an important resource to Alaskan inhabitants. During its unrestricted migrations, the WACH comes in contact with 10,000 to 15,000 people of northwestern Alaska (Herbert Brownell, BLM, pers. comm.), many of whom depend on caribou to maintain their subsistence lifestyles. Caribou provide a seasonally but locally avaialable supply of meat that costs little to obtain. Sport hunting of caribou by both Alaska residents and nonresidents brings tens of thousands of dollars to the Alaskan economy in the forms of license fees, guiding and outfitting fees, air charter, and other hunting-related costs. Although the WACH does not now support much sport hunting, it may become more important in the future. From a nonconsumptive standpoint, the WACH is a substantial and highly visible component in the ecosystem and adds significantly to the wilderness values of public lands in northwestern Alaska. It has been formally designated in the Alaska National Interest Lands Conservation Act as a resource of "national and international significance."

Conclusions

Clearly, the needs of both the domestic reindeer industry and the Western Arctic Caribou Herd are important in the future management of public lands in northwestern Alaska. Decisions favoring either reindeer or caribou will have wide-ranging and potentially deleterious effects on the other. It is imperative that decisions be made to minimize the potential overlap of the two uses and thus minimize the conflicts.

Impacts of any decision go beyond the environmental considerations normally associated with conventional grazing conflicts. The commercial reindeer industry offers an opportunity for economic development of the region, but caribou are essential for maintaining the traditional subsistence lifestyles of many Alaskans. If reindeer and caribou are to both provide their respective economic benefits, we feel that interactions of the reindeer industry with wild caribou should be minimized. Before expanding onto caribou range, the reindeer industry managers should stock ranges already dedicated to reindeer grazing, and not used by caribou, to their potential. With this approach, close herding technqiues and reasonable stocking rates for reindeer on arctic tundra ranges can be developed. Both land managers and reindeer owners should explore the potential and realistic future of commercial markets for reindeer meat and by-products and gain understanding of the industry's economic effects on northwestern Alaska. Study of the economic effects may show that the actual benefits of the reindeer industry do not compensate for its impacts on the Western Arctic Caribou Herd.

It is imperative that public land managers be fully aware of the significance of their decisions. Unconventional land use problems will require equally unconventional approaches and solutions. Fortunately, in Alaska and particularly in the case of domestic reindeer grazing, it is possible to assess the effects and allow reasonable growth of the industry rather than try to ease the impact of previous and ongoing resource use, as has occurred on public grazing lands in the American West. We hope that public land managers in Alaska will take advantage of this opportunity.

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Old-growth Forests as Wildlife Habitat

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Introduction

Land management is wildlife management, and timber management is the dominant land use in the Pacific Northwest. Of the timber management objectives that most influence wildlife in the Northwest, the programmed liquidation of old-growth forests has become the focal forestry-wildlife issue. Old-growth forests are being eliminated for two reasons, both economic: (1) old-growth forests contain large volumes of valuable wood; 100 acres (40 ha) of old-growth Douglas-fir (*Pseudotsuga menziesii*) currently sells for about $1.6 million on the stump. (2) Young stands grow wood more rapidly than old-growth stands. Public forestlands make up about 49 percent of the commercial forestland west of the crest of the Cascade Range in Oregon and Washington. These forestlands are extensive—equal in size to the states of Vermont and Massachusetts combined. Because public forestlands are mandated for mutliple-use management, they are clearly the key to wise management of old-growth forests and associated wildlife.

In this paper we propose to (1) acquaint the reader with the pertinent characteristics of old-growth forests of the Pacific Northwest, (2) identify a wildlife community associated with old-growth forests, (3) explore current management problems and strategies for old-growth forests, and (4) suggest action to acquire information that will strengthen the basis for management of old-growth forests on public lands.

Old-growth Forests

Temperate coniferous forests reach their maximal development in extent and physical size in the Pacific Northwest. Forests of western Washington and Oregon are almost totally dominated by conifers—big conifers. Of the ten coniferous genera found here, each is represented by its largest and often longest-lived species, and sometimes its second and third largest species as well (Franklin and Dyrness 1973). The term "old-growth forest" takes on particular meaning when one considers the great size [3-6 feet (1-2 m) diameter at breast height and 165-295 feet (50-90 m) tall] and longevity (500 plus years) commonly attained by individual trees. These large, long-lived trees do not occur as scattered individuals but as continuous, extensive evergreen forests. At the time of settlement (mid-1800s) conifer forests covered most of western Oregon and Washington. With an assumed fire frequency of about 350 years, Munger (1930) suggested that 75 percent of the forests were older than 150 years. Some 82 percent of the area is still classed as forestland (Franklin and Dyrness 1973) but now less than a third of the forest stands in western Oregon are composed of trees that average more than 21 inches (53 cm) diameter at breast height (D. Gedney pers. comm.).

Old-growth coniferous forests in the Pacific Northwest are significantly different from younger stands. A work session sponsored by the USDA Forest Service to explore the ecological characteristics of old-growth Douglas-fir forests was held in Corvallis, Oregon, in February 1977. This session served to generate a multi-authored USDA Forest Service General Technical Report (Franklin et al. 1981); we have drawn heavily on the information and ideas presented in that publication.

Differences in structure, function, and composition between young and old-growth forests are attributable to three primary structural components of old-growth forests: large live trees, large snags, and large logs (Franklin et al. 1981). In the Pacific Northwest, individual trees typically begin to assume old-growth characteristics at 175-250 years of age. These characteristics include: irregular, large, coarse branch systems; a deep crown; large size; and, frequently, broken tops. Old-growth trees at death form the large snags characteristic of old-growth stands (Cline et al. 1980). As snags age and fall they contribute the third characterisitc of old-growth forests—large logs (Maser et al. 1979).

Douglas-fir, a pioneer species in the Northwest, frequently dominates old-growth stands because of its longevity. Shade-tolerant climax species, such as western hemlock (*Tsuga heterophylla*) or western redcedar (*Thuja plicata*), form secondary canopies. Old-growth forest stands are structurally complex, with great vertical development and considerable intra-stand variability. The intra-stand horizontal variability or patchiness is introduced by chance environmental events (e.g., lightning, windthrow, insect infestation) that occur during their long development. The structural complexity, great vertical development, and horizontal patchiness of old-growth forests allow a relatively high number of wildlife species and individuals to exist there.

Wildlife of Old-growth Forests

Old-growth forests were at one time considered a rather sterile habitat (Tevis 1956); the terms "biological deserts" and "cellulose cemetaries" were once common buzz words. But old forests, in fact, support diverse and abundant animal communities (Johnston and Odum 1956, Haapanen 1965, Wight 1974, Mannan 1977, Edgerton and Thomas 1978). Most importantly, older forests harbor a group of animals that apparently evolved as specialists taking advantage of the specialized habitats the unique structure of these stands affords.

In the Douglas-fir region of the Pacific Northwest, the northern spotted owl is the most prominent old-growth specialist; it comes closest of any known vertebrate species to being a true old-growth obligate (Forsman 1980). Although lists are not unanimous, as many as 18 bird and mammal species have been identified (Table 1) as finding optimum habitat (i.e. reach greatest densities) in old-growth forests in the Douglas-fir region (Mannan 1977, Meslow 1978, Franklin et al. 1981).

In the mixed-conifer forests of the western Sierra Nevada, Verner and Boss (1980) identified 24 species of breeding birds and five species of mammals that

Table 1. Wildlife that find optimum habitat for breeding or foraging or both in old-growth Douglas-fir forests, western Oregon and Washington.

Group	Common name	Scientific name
Birds	Goshawk	*Accipiter gentilis*
	Northern spotted owl	*Strix occidentalis caurina*
	Bald eagle	*Haliaeetus leucocephalus*
	Vaux's swift	*Chaetura vauxi*
	Pileated woodpecker	*Dryocopus pileatus*
	Hammond's flycatcher	*Empidonax hammondii*
	Pine grosbeak	*Pinicola enucleator*
	Townsend's warbler	*Dendroica townsendi*
Canopy mammals	Silver-haired bat	*Lasionycteris noctivagans*
	Long-eared myotis	*Myotis evotis*
	Long-legged myotis	*Myotis volans*
	Hoary bat	*Lasiurus cinereus*
	Red tree vole	*Arborimus longicaudus*
	Northern flying squirrel	*Glaucomys sabrinus*
Ground mammals	California red-backed vole	*Clethrionomys californicus*
	Coast mole	*Scapanus orarius*
	Marten	*Martes americana*
	Fisher	*Martes pennanti*

found optimum conditions only in old-growth forest (large tree stages); an additional three bird and nine mammal species found suitable habitat only in the large tree stages of mixed-conifer forests. Birds have probably received more attention than mammals because they are easier to inventory. Published information (Wight 1974, Edgerton and Thomas 1978), and current research (R. W. Mannan pers. comm.) indicate that at least 19 species of birds find optimum breeding habitat only in mature and old-growth forests of ponderosa pine (*Pinus ponderosa*) and Douglas-fir in eastern Oregon. Obviously a significant number of wildlife species are closely associated with old-growth forests.

The Problem

Old-growth forests are rapidly being liquidated on lands managed by USDA Forest Service (USFS) and USDI Bureau of Land Management (BLM) in the Pacific Northwest. In western Oregon and Washington succession will be truncated at the stand rotation age of 50 to 80 years. Some BLM districts in Oregon have no more than 10 years of old-growth remaining at the current rate of cutting, and within 20 to 30 years all old-growth stands will have been liquidated (Luman and Neitro 1980). The situation on USFS lands is not so immediately critical. In the

Pacific Northwest Region, the cut of old-growth is programmed to continue for an average of 65 years on various National Forests (A. C. Twombly pers. comm.). But on the Siuslaw National Forest, in the Oregon Coast Range, only small pockets of old-growth remain. Current timber management plans for the Siuslaw call for management to retain only 13,488 acres (5,459 ha), or 2.2 percent of the forest's 624,883 acres (252,890 ha) in mature or old-growth stands.

Little old-growth forest remains on private lands in the Pacific Northwest and the owners have little incentive to manage for older forests. State forestry agencies in Washington and Oregon have been unwilling to consider managing their holdings to retain old forest stands because it precluded maximum economic return to the state coffers.

Management Problems and Strategies

Although individual species closely associated with old-growth forests (e.g., spotted owl and pileated woodpecker) have served to focus attention on the old-growth issue, those involved—foresters, planners, and wildlife biologists alike—would prefer to manage for the old-growth community. It is fortunate that the key species identified to date in western Oregon and Washington, the northern spotted owl, uses large acreages of old-growth. Based on radio-telemetry of 14 spotted owls, the minimum amount of old-growth forest within the home range of a pair was 1,000 acres (400 ha) (E. D. Forsman pers. comm.). Management efforts directed at this species should therefore accomplish management of the old-growth communities where the bird is found (Samson 1980).

The large snags and logs that we take for granted in the second-growth timber of today are carry-over components of the old-growth forests we have cut down. Such large woody debris has important ecological implications in terms of mineral cycling, nutrient immobilization, nitrogen fixation, fire, and wildlife habitat (Maser et al. 1979). And the fact is that present timber management strategies and goals do not plan for either the maintenance or replacement of these old-growth components in managed forests of the future.

As a result of the timber harvest pattern, it already is difficult to maintain a distribution of old-growth that ensures a continuous distribution of associated wildlife. It is the clear policy of both the BLM and USFS to manage for viable populations of all species of native wildlife using their lands. A viable population consists of the number of individuals distributed throughout their range that is sufficient to perpetuate natural, self-sustaining populations. Although this policy should ensure the reasonably equitable distribution of old-growth forests and their associated wildlife on federal forest lands, it has yet to be widely and formally implemented via the land management planning process.

Federal land is not the total solution to ensuring suitable distribution of old-growth forests. There is little federal land in the Coast Range of northern Oregon or southwestern Washington. In this strip of land straddling the Columbia River, about 120 miles long by 80 miles wide (190 by 130 km), it is doubtful that old-growth forests of any significant extent will be maintained. In addition, the BLM and USFS lands bordering the area to the south are among the most heavily cut-over holdings of the two agencies in the Northwest. The old-growth forests of the Olympic Peninsula of Washington (Olympic National Forest and Olympic National

Park) are already isolated from the Cascade forests by over 60 miles (100 km) of urbanization along Puget Sound. Unless a connecting chain of habitat can be developed, the Olympic Peninsula must be treated as an island. In general, a series of separate habitats each with an "effective population size" (Franklin 1980, Soule 1980) will require the commitment of a greater land base than will a continuous distribution of animals. Luman and Neitro (1980) proposed a corridor approach to minimize isolation of old-growth areas from each other if a fully integrated, old-growth management scheme could not be implemented. Samson (1980) reviewed management of nongame birds, drawing on theory developed in island biogeography, and suggested management based on the habitat needs of the species requiring the largest minimum area. The planning skills and biological insight required to appropriately intersperse old-growth stands in a matrix of managed stands will be a demanding assignment.

Action Suggested

In this paper we have called attention to several lists of wildlife species that appear to find optimum habitat in old-growth forest. There is, however, a paucity of quantitative information on the abundance of wildlife that inhabit old-growth forests and even fewer hard data exist on the ecological relationships of these animals with such forests. We view this lack of information as a most serious gap in our knowledge of wildlife-habitat relationships. Forest management is about to truncate succession—eliminate a distinct type of forest (ecosystem)—and wildlife biologists cannot be sure they know all the species involved, let alone the relationships of those species to each other and to the forest system as a whole.

We propose that the responsible forest management agencies, with the assistance of wildlife agencies and the private sector, give immediate high priority to acquiring the information necessary to make decisions concerning management of old-growth forests and their associated wildlife based on reliable biological data, not just suspected relationships. Some needed pieces of information have already been collected or are being collected, but, overall, the research approach has been a piecemeal reflection of the interests of individual researchers or organized groups. Although funding for the task should arise from multiple sources, it is essential that the program have centralized direction.

The approach we advocate is simple. It involves two steps: (1) obtain a measure of abundance for wildlife species in unmanaged old-growth forests compared to younger, managed forests in each major forest zone. (2) Identify the ecological relationships of animals within old-growth forests and give priority to species associated with older stands (from 1 above). Only when armed with this information can the habitat needs of wildlife species associated with old-growth forests be given the consideration they demand and that the law requires.

While this paper was being developed, the research arm of the USFS held meetings to identify wildlife research needs in western Washington and Oregon. Agency, university, industry, and special interest organizations were present and called attention to the immediate importance of old-growth wildlife research needs. Management of old-growth as wildlife habitat surfaced in the BLM's land management planning process as the key issue in several western Oregon districts in 1980. State wildlife departments in the Pacific Northwest have active, independently supported nongame programs. These state nongame programs relate especially well to "sensitive" old-growth associated species; the endangered species, migratory bird, and mammals and non-migratory bird programs of the U.S. Fish and Wildlife Service also share responsibility for old-growth wildlife management. Two major timber companies have funded research efforts dealing with threatened species associated with old-growth. The issue has the support of the conservation organizations. Universities and the research divisions of the forestry and wildlife agencies have the interest and the expertise to conduct and supervise the research.

The time is right.

Ecological and economic stakes are high.

The players are assembled and ready.

We need a commitment to do the job.

It is our hope that this conference will help stimulate that commitment.

Acknowledgments

The late Howard M. Wight did much to sensitize biologists and managers to the issue of old-growth forest wildlife in the Pacific Northwest. R. G. Anthony, E. D. Forsman, R. W. Mannan, and D. Q. Thompson reviewed drafts of this paper. This is a contribution of the Oregon Cooperative Wildlife Research Unit: Oregon Department of Fish and Wildlife, Oregon State University, U.S. Fish and Wildlife Service, and the Wildlife Management Institute cooperating. The USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, LaGrande, Oregon, funded a problem analysis of the habitat requirements of old-growth wildlife in the Pacific Northwest. Oregon State University Agricultural Experiment Station Technical Paper 5751.

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Managing of Federal Lands for Production and Use of Wildlife and Fish

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Introduction

The people of the United States collectively own nearly 725 million acres (293 million ha) of forest and rangeland. These lands are administered for them by a number of federal agencies. Eighty-nine percent of the federal land is managed by either the Bureau of Land Management or the Forest Service. The Department of Defense, Fish and Wildlife Service, and National Park Service, along with several other federal agencies, administer the remaining 11 percent of the federal forest and rangeland. Wildlife and fish are a legally recognized and required product of federally owned lands.

The USDA Forest Service, in cooperation with state wildlife and fish agencies, identified the level and ownership where wildlife and fish use occurred in each state as part of the 1980 Renewable Resources Planning Act Assessment (Schweitzer et al. 1978). Information on hunting and fishing provided some of the most tangible evidence of the use of wildlife and fish on federally owned land.

In this paper, we describe the demand for wildlife and fish resources, identify some of the important big game and threatened or endangered species associated with federally administered lands, and identify the uses of these resources. The future for wildlife and fish resources associated with these lands is dependent upon how the land management planning processes of the various management agencies are implemented.

The Bureau of Land Management is mandated by the Federal Land Policy and Management Act of 1976 (P.L. 94-579) to manage its lands "on the basis of multiple use and sustained yield unless otherwise specified by law," and in a manner "that will provide food and habitat for fish and wildlife." In addition, land management plans are to be developed in accordance with the Classification and Multiple-Use Act of 1962 (P.L. 88-607).

Multiple-use has been a part of Forest Service management policy since the inception of the National Forest System (Wengert et al. 1979). That policy was strengthened by the Renewable Resources Planning Act of 1974 as amended by the National Forest Management Act of 1976 (P.L. 93-378 and P.L. 94-588). This legislation requires land management plans for the improvement and monitoring of renewable resources in accordance with the Multiple-Use and Sustained Yield Act of 1960 (P.L. 86-517). It also requires regulations be put into affect which would insure that land management plans are prepared in accordance with the National Environmental Policy Act of 1969 (P.L. 91-190). Recent federal land management planning legislation has also established a mandate requiring managers to maintain and enhance future production and use of wildlife and fish. Equitable consideration will depend on establishing measures of consumption and production for wildlife and fish comparable to those for other renewable resources. Assigning each land management unit an equitable share of production to meet national and regional needs commensurate with local needs is one of the challenges to federal land management planning. Generally this means some adjustment to allow each individual federal land management program to help meet national, as well as local, needs.

Such planning is further complicated by the fact that when land is managed for one renewable natural resource, all renewable natural resources are influenced. Equitable consideration of wildlife and fish resources in planning processes is hampered by deficiencies in knowledge and methods about the resource and analytical techniques. Using the ecological concepts of diversity, species richness, and unique habitat requirements, Thomas and others (1979) developed a means of assessing impacts of land management on wildlife and fish in forest and range habitats. Knowledge and methods described by Salwasser and Tappeiner (1981), Mealey and Horn (1981), and Everest and Meehan (1981) define applications of the current state of the art.

Uses of Wildlife and Fish

Uses of wildlife and fish have been characterized as commercial, ecological, and social (Schweitzer et al. 1980). Commercial uses are those which involve values generated by the sale or barter of wildlife and fish products. These uses are most clearly defined and represent the smallest group of species. Social (recreational) uses involve a large group of wildlife and fish species. Such recreational uses are generally well defined, albeit difficult to measure. Ecological uses are those which express environmental value. They are the most difficult to define and affect all species.

The 1980 assessment of the forest and rangeland situation in the United States reported that uses of wildlife and fish are increasing nationwide. The projected rate of increase varies with the kind of use and section of the country. For example, use (and prices) of commercial fish and furs has risen substantially in recent years. Commercial fish use is expected to increase steadily while the use (and prices) of furs will likely follow fashion trends. Future recreational use of fish and wildlife is also expected to increase. The demand for fishing opportunities has been growing fast, and a 20 percent increase is expected in freshwater fishing during the next 10 years. Hunting and nonconsumptive uses of wildlife are expected to experience more modest increases. Ecological values of wildlife and fish include the desire that each species be preserved and that the current community of species be maintained on designated areas of land. The Endangered Species Act of 1973 (P.L. 93-205) and the National Forest Management Act are expressions of the people's concern for ecological values of wildlife and fish. The future level of these values is expected to remain relatively high compared to competing values of other resources on forest and rangeland (Schweitzer et al. 1980).

Habitats on Federally Managed Lands

Because federally managed lands are owned by the nation as a whole, their management reflects national as well as state and local values. It should be emphasized, however, that the contribution of federally managed land to the production of wildlife and fish is not independent of habitats and their management on nonfederal ownerships. The local importance of nonfederal ownerships to winter and production habitat is well documented. All ownerships are essential to the production of wildlife and fish resources.

Nationwide, federally managed land provides important habitat for many species of wildlife and fish, but particularly for production and use of large ungulates and carnivores. Fourteen native big game species, including the wild turkey, are produced and used on federally managed land in the contiguous 48 states (Appendix 1). Three others—Dall sheep, muskox, and polar bear—occur on federally managed land in Alaska.

Ninety-five percent of the federally managed land is in the 11 contiguous western states[1] and Alaska. Thirty-eight species out of a total of 87 federally listed threatened and endangered species west of the Mississippi River (including Alaska) occur on National Forest System and Bureau of Land Management lands. The total number of threatened and endangered animal species listed by states and federal agencies varies from 4 to 80 per state in the 11 contiguous western states and Alaska (Schweitzer et al. 1980). Western national forests provide the majority of identified habitat known to be required for 13 percent of those found on National Forest System lands. This includes threatened and endangered species such as the Little Kern golden trout, unarmored threespine stickleback, Gila trout, Kendall warm springs dace and California condor. Federal land in the eastern United States contributes the majority of habitat for threatened and endangered species such as the Kirtlands warbler, red-cockaded woodpecker, Peregrine falcon, eastern timber wolf, and bald eagle.

The red-cockaded woodpecker, an endangered species associated with the pine forests of the southern United States, is just one example of the role played by federally owned lands in preserving threatened and endangered species. Jackson (1978) estimated that 84 percent of red-cockaded woodpecker colonies are found on federal lands; however, Lennartz and McClure (1979) believe there may be more of these birds on private land. Nesting habitat has declined drastically over

[1]Eleven contiguous western states: Washington, Oregon, California, Arizona, Nevada, Utah, Idaho, Montana, Wyoming, Colorado, New Mexico.

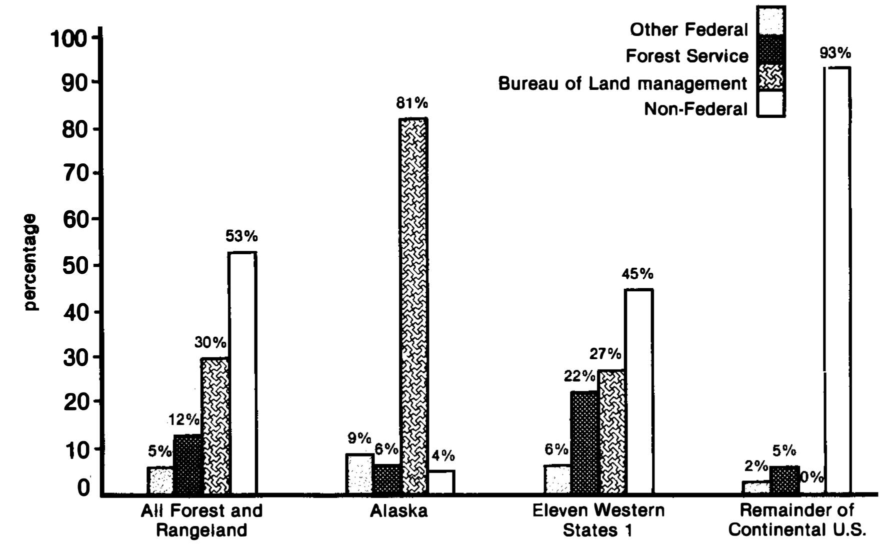

Figure 1. Forest and range land areas in the United States by ownership–1977.

the past 40 years, and continues to decline (Lennartz and McClure 1979). On unmanaged forest lands, hardwood encroachment into pure pine stands results in red-cockaded woodpeckers being excluded by other woodpecker species. And on intensively managed, private, industrial pine forests, short rotations for pulpwood, and even sawtimber, do not provide the continuing supply of mature pines required by the woodpecker for excavating nesting and roosting cavities. Because federal agencies are required by law to improve the status of threatened and endangered species, the long-term prospects for the woodpecker's survival depend primarily on the rather small percentage of total eastern forest land under federal management.

Production and Use on Federally Managed Land

Extensive habitats for large ungulates and carnivores are found primarily on federally managed land in the 11 contiguous western states, with consumptive harvest and nonconsumptive uses of wildlife and fish also largely oriented toward federally managed land. Two-thirds or more of the harvest of eight big game species taken by hunting during the mid-1970s came from federally managed land in this geographic area (Figure 2). Among the big game species we considered, pronghorn antelope were harvested on federal land in the lowest proportion relative to their harvest on other land. Yet, federal land contributions to the pronghorn antelope harvest are twice that of private land. The harvest of mule deer on federal land in the mid-1970s was more than twice the harvest on private land, although mule deer are widely distributed across public and private forest and rangelands. A major factor in the distribution of harvests for mule deer and pronghorn antelope

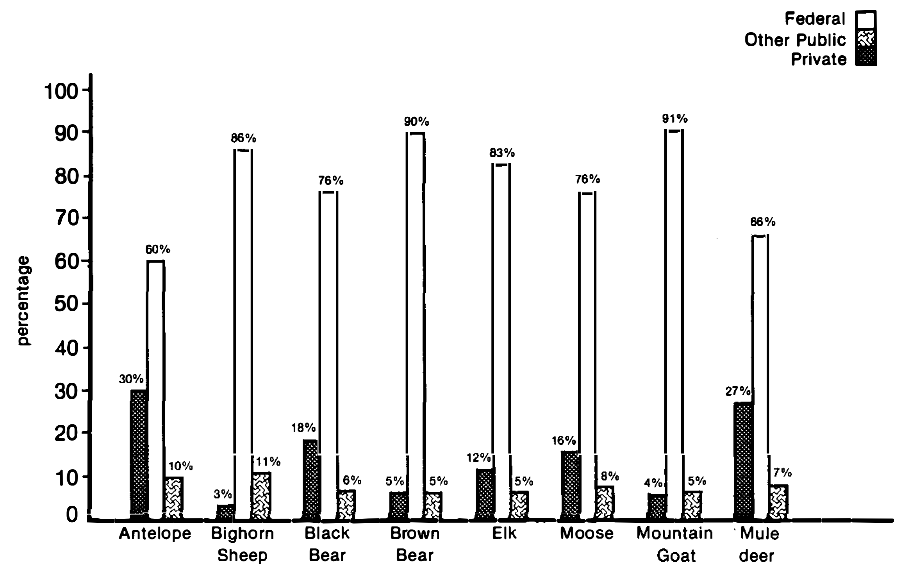

Figure 2. Harvest of big game species by land ownership in 11 contiguous western states–mid-1970s (data from Schweitzer et al. 1978).

is the easy inexpensive access available on federal lands. Species with restricted habitats, such as bighorn sheep, mountain goats, and grizzly bears, are found and harvested almost exclusively on federally managed land. In the State of Washington, however, 90 percent of the bighorn sheep harvest comes from state-managed public land.

The production and use of wildlife and fish species in Alaska have been closely tied to federal management because, until recently, 96 percent of the state was under federal management. Harvests of Dall sheep and most caribou and moose came from federal land in Alaska.

The importance to fish and wildlife species of federally managed land in eastern forests is different from the situation in the western United States. Considering the low proportion of the total eastern forest acreage and federal management, it is not likely that federal lands harbor a major proportion of the total population of any major game species.

Access

Federal lands throughout the nation provide relatively easy and inexpensive access to animal populations. Estimates for days of hunting spent on different ownerships were provided by states for the 1980 National Assessment of Wildlife and Fish. Table 1 provides a summary of the percentage of hunting days for selected forest and rangeland wildlife species that occurred on different land ownerships within the continental United States. Almost without exception, these popular game species were sought in relatively greater amounts on federally managed land (Table 1) than would be expected, based on the relative quantity of

Table 1. Average percentages of days of hunting for selected species in the contiguous states during the mid-1970s, by land ownership with RPA Section.[a]

RPA section hunted species	Ownership Federal	Other public	Private
Northeastern States			
Rabbits, hares	15	20	65
Forest grouse	15	15	70
Deer	10	20	70
Turkey	25	15	60
Bear	30	15	55
North Central States			
Rabbits, hares	10	20	70
Forest grouse	15	20	65
Deer	20	20	60
Turkey	30	25	45
Bear	50	25	25
Southeastern States			
Rabbits, hares	20	20	60
Forest grouse	50	20	30
Deer	45	20	35
Turkey	45	25	30
Bear	60	0	40
South Central States			
Rabbits, hares	20	10	70
Forest grouse	40	20	40
Deer	35	15	50
Turkey	45	20	35
Bear	40	10	50
Great Plains			
Rabbit, hare	20	10	70
Prairie grouse	25	10	65
Deer	10	0	90
Turkey	30	10	60
Antelope	10	5	85
Rocky Mountain States			
Rabbit, hare	65	10	25
Forest grouse	90	0	10
Prairie grouse	60	5	35
Deer	60	10	30
Turkey	55	10	35

Bear	80	5	15
Antelope	55	10	35
Elk	85	5	10
Moose	80	5	15
Pacific Coast States			
Rabbit, hare	65	5	30
Forest grouse	55	20	25
Prairie grouse	30	10	60
Deer	55	5	40
Turkey	25	10	65
Bear	75	5	20
Antelope	70	10	20
Elk	65	15	20

[a]Schweitzer et al. 1980

federally managed land (Figure 1). Continued inexpensive, easy access available on federal ownership is expected to result in an increase in the number of hunting days on federally managed land in the future relative to that on other ownerships. In the South, for example, industry lands provide a major hunting opportunity, but private companies are increasingly making their lands available on a lease or fee basis (Tomlinson 1979). And as demands for timber products increase, it is likely that management on private lands will increasingly emphasize timber production and deemphasize wildlife. Opportunities for hunter access will become fewer, more costly, or both (Tomlinson 1979, Chessman 1979). Nationwide, federal lands will receive increasing pressure for recreational uses of wildlife and fish, an increase disproportionate to the relatively small land base, as access elsewhere becomes more restricted.

Future Opportunities

Enhancement of wildlife and fish production and use on lands managed by the Forest Service and Bureau of Land Management will be a high priority for future land managers. These lands probably represent the best hope for sustenance of most native big game species of the United States as human populations increase and the amount of wild land decreases. Integrated resource management is required of federal land managers; however, difficult decisions on evaluation of competing values continue to face the federal land managing agencies. The wildlife and fish populations on federal lands and their use by people greatly contribute to the value of these lands. Recent land management planning requirements provide a rational process that is intended to assure that decisions will be made in the best interest of the people of this nation.

Appendix 1. Common and scientific names of species referred to in the text.

Common Name	*Scientific Name*
Eastern timber wolf	*Canis lupus*
Cougar*	*Felis concolor*
Black bear*	*Ursus americanus*
Brown bear	*Ursus arctos*
Grizzly bear*	*Ursus arctos horribilis*
Polar bear	*Ursus maritimus*
Moose*	*Alces alces*
Pronghorn antelope*	*Antilocapra americana*
Elk*	*Cervus elaphus*
Peccary*	*Dicotyles tajacu*
Mule deer*	*Odocoileus hemionus*
White-tailed deer*	*Odocoileus virginianus*
Mountain goat*	*Oreamnos americanus*
Dall sheep	*Ovis dalli*
Bighorn sheep*	*Ovis canadensis*
Muskox	*Ovibos moschatus*
Caribou	*Rangifer tarandus*
Peregrine falcon	*Falco peregrinus*
Eastern bald eagle	*Haliaeetus leucocephalus*
California condor	*Gymnogyps californianus*
Wild turkey*	*Meleagris gallopavo*
Red-cockaded woodpecker	*Picoides borealis*
Kirtlands warbler	*Dendroica kirtlandii*
Threespine stickleback	*Gasterosteus aculeatus*
Kendall warm springs dace	*Rhinichthys osculus thermalis*
Little kern golden trout	*Salmo aquabonita whitei*
Gila trout	*Salmo gilae*

*Native big game species produced and used on federal land in the continental United States.

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Sustained Support for Resource Management: The Reality and the Promise

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I want to share with you a worrisome conviction I have developed about the widening gap that is developing in our country between supply and demand in natural resources. I am also concerned about the long-term consequences of permitting that gap to widen when we know how to prevent it, but won't take the timely actions necessary to avoid those consequences.

Having sounded a very pessimistic note, I want to explain my rationale and hopefully suggest some ways to narrow or to bridge the gap.

All of the analyses of current condition and trend of the land and its resources, and projections of supply and demand, domestic and global, present very similar conclusions. Population is expanding at an alarming rate, with the highest birth rates in the most impoverished or less-developed nations. Projections of demand for food and fiber for both domestic and international markets is growing more rapidly than is our domestic productive capability. Simultaneously, we are wasting our most vital resource, the productive soils of the nation, at an alarming rate—some 3 million acres (1.2 million ha) of farm and forestland being converted to "non-productive" uses such as suburban home sites, supermarkets, highways, and the other essentials of an affluent society; another 3 million acres (1.2 million ha) equivalent is being lost annually to erosion from wind and water. Valuable terrestrial and aquatic habitats are being lost as conservation features of previous decades—shelterbelts, grassed waterways, and protected fencerows—come under the plow. The forest lands of the nation on average function at about three-fifths the growth rate of a natural fully-stocked stand, which is an innocuous way of saying less than half of what the better sites ought to be producing using current technology. And the nation's rangelands function at about half their capacity to produce forage for domestic livestock and habitat for wildlife, not to mention the myriad benefits that flow from improved hydrologic condition of some 800 million acres (324 million ha), about one-third of the land area of the nation.

The point of telling you what you already know is to emphasize that despite substantial progress in the last two decades, *we are still losing ground.*

We have made substantial progress in improving air and water quality; in limiting development activities on sensitive sites; in improving management practices on wild lands to reduce or alleviate various impacts on other resource values; and in other ways, resource management activities on both public and private lands have improved in terms of lessening environmental impacts. But we still have substantial room to improve.

As a society, we have set aside by law of the land many areas of the country to protect their special qualities as components of the National Parks, Refuges, Wilderness, and Wild and Scenic River Systems, and other areas have been analyzed and are under consideration for possible future inclusion in one of these categories. Of the 728 million acres (294.8 million ha) of Federal land, about 205 million acres (83.2 million ha) have already been designated and another 35-40 million acres (14.1-16.3 million ha) have been recommended or are available for possible inclusion if society decides to add them to the system.

In my view, this richest nation on earth can well afford to protect the quality of our environment and to preserve the best of the scenic and natural wonders and places. And I personally would have it no other way. I do not believe, however, that the Wilderness Act should be used merely as an instrument of classification to preclude development in the absence of very special qualities in the areas proposed for Wilderness.

We also need to keep in mind that only the highly developed and affluent nations do anything about preserving natural areas and protecting the quality of the environment. It is only after the survival needs are satisfied, i.e., food, clothing, and shelter, and a reasonable order of comfort and affluence comes into the lives of people that they begin to think about the long-term future. I would not wish to put to the test the relative priority the American public would place on jobs vs. protection of the environment if we were to again approach a "Great Depression."

I raise the specter of reversal, albeit a remote possibility, to emphasize my basic thesis: it is time—it is past time—for environmentalists, for conservationists, for business and industrial leaders, for public officials, and many others whose lives are directly affected by the state of the economy AND the quality of our environment *to commence working together*. We need a concerted effort by knowledgeable and interested people in support of sound, long-range policies and programs affecting the productivity of this nation's farm, forest, and rangelands.

It is not too much of an exaggeration to say that we are a nation of special interests. Our system is designed to encourage people of like mind and interest to band together to exert influence on the public decision-making process, to advocate their special viewpoint on any and all issues. We have a neat classification system for the different forms of interest groups. The generic classes are usually labeled as (1) public and (2) special, the former claiming pure motives and deep insight into cosmic verities and the latter knowing beyond doubt that "what's good for G.M. is good for the nation." My purpose is not just to poke fun at our foibles, since I must include the American Forestry Association (AFA) and me in there someplace, but rather to suggest that none of us truly speaks for "the public"—we each speak for "our public." Our system works as well as it does, I suppose, because of the combined effects of us all, some pulling together, others attempting to nullify. Decisions tend to focus on narrow issues rather than broad subject areas; to coin a new phrase, we tend to look at the trees instead of the forest.

That worrisome conviction I mentioned earlier is that while we pursue our various interests, time slides by. We are moving from a history of resource surplus *toward* a future of resource scarcity sometime after the turn of the century. That is the dismal scenario predicted by the 1980 Resources Planning Act and Resources Conservation Act analyses of supply and demand projected to the year 2030, and by the Global 2000 report to the President—*if*, as all three reports carefully qualify, *if* we continue on our present course.

The November election was clearly a mandate for change, or at least so believe 44 out of 50 states. Precisely what form that change will take is still debatable. Cuts in the Federal budget, taxes, and in Federal regulation; reordering priorities among many Federal and State cooperative efforts; stimulating productivity in both the public and private sector; and lessening the elapsed time required to conform to environmental, health, and safety standards and procedures are on the agenda of this administration.

From all indications, the current emphasis on budget cuts suggests that little if any increases in natural resource programs will occur until there are clear signs of improvement in the economy. It is doubtful that resource programs will be increased during a period when social programs are being sharply reduced.

Many conservationists have voiced concerns as to whether or not the new administration will attach high priority to commercial uses of public lands for the development of energy, minerals, timber, and other such uses to the detriment of the environment, to fish and wildlife habitat, and to air and water quality. Changes will indeed be made and are being made. Whether or not those changes will be beneficial or harmful to the American public will be judged again in 1984. In the meantime, I believe we must evaluate each action or proposal as it develops, rather than to react prematurely to some caricature portrayed by the media or by special interest groups. It is, after all, to our mutual benefit for this administration to be successful in strengthening our economy and, in doing so, maintaining a healthy environment.

Being a non-partisan conservation organization, AFA intends to support the administration in its mission; we will take issue when we believe actions or decisions are ill-advised.

But in the long term, we must develop support for the long-range planning concept embodied in the RPA and RCA legislation. This is something too important to our future to permit it to fall into disrepair through misuse or lack of use. There is no other mechanism in the whole Federal system which provides disparate interests an opportunity to make their needs known in the development of a multiyear program affecting both publicly-owned lands (Federal and State) and privately-owned forest, farm and range lands.

We know that renewable natural resources and the uses of wild lands cannot be turned on and off like a spigot. For example, every single tree that will be needed for lumber, plywood, and paper and other wood products at the turn of the century, to satisfy the needs of some 290-300 million of us, is growing NOW. It is already too late for us to plant to satisfy our needs in the year 2000—we should have done that in the 1960s. Because we didn't, in 2000 we will cut more heavily than we would otherwise have had to cut, which in turn means greater impacts on water quality, on habitat, and, of course, on price of the end product.

The same can be said of many other needs. The winter sports complex or the developed recreation area needed by the year 2000 must be started at least a decade ahead of the projected need. A deteriorated range can't be restored in less than a decade. And how long does it take to recover a viable population of an endangered species? or an extinct species?

My whole thesis is that there is only one workable, or at least a potentially workable, long-range resource planning game in this town. The process defined by the Forest and Related Rangeland Resources Planning Act of 1974 is our best hope for the future. That hope, that promise, can die aborning if those who understand natural resources do not support the process, if they do not insist that natural resources programs be sustained at adequate levels of investment to assure that this generation enhances the productivity of our nation for the benefit of *future* generations.

So let us—those of us who are most concerned with sound management of our resources—work to bring into being our nation's full resource potential. Let us make the other half happen in the next two decades.

Effect of Oil and Gas Development on Elk Movements and Distribution in Northern Michigan[1]

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Introduction

Elk (*Cervus elaphus*) were successfully reintroduced into Michigan in 1918 (Stephenson 1942). From the time they were released near the Pigeon River in the northern Lower Peninsula (Figure 1), the elk prospered and expanded, and by the 1950s, habitat damage and agricultural depredation began to occur (Moran 1973). However, a herd reduction program in 1964 and 1965, coupled with increases in poaching, human development, habitat succession, and meningeal worm infestations, resulted in elk depletion so severe that by 1970 wildlife managers were concerned about the viability of the Michigan elk herd.

In July 1970, oil was discovered in what is now the Pigeon River Country State Forest (PRCSF). The state-issued leases were obtained by oil companies in 1968, as they had been since being authorized by Act 17, P.A. 1921. Oil development in this part of the state had met with limited success and oil companies had rarely utilized the leases for development. This provided the state with a source of revenue and little or no disturbance resulted. After the 1970 discovery, however, hydrocarbon development in the PRCSF increased drastically and the threat of environmental degradation prompted the Michigan Department of Natural Resources (MDNR) to deny drilling permits to Shell Oil Company for a parcel of land in Corwith Township. In the ensuing court case (Corwith 1-22), one of the prime considerations was the effect hydrocarbon development would have on the elk herd.

Before the Corwith 1-22 case was settled, the MDNR prepared an environmental impact statement for hydrocarbon development in the PRCSF (MDNR 1975) and held public hearings to review it. Included in this statement was a series of compromises and possible consequences associated with each. In 1976, one of the compromises was agreed to by both the MDNR and the oil companies involved.

Shortly after this consent decision, a suit was filed against the MDNR and Shell Oil Company by West Michigan Environmental Action Council and the development which had just begun was again halted. After an appeal of the lower court decision was filed, on February 20, 1979, the Michigan Supreme Court ruled that because of the detrimental effect hydrocarbon development would have on elk, oil drilling in the PRCSF would be banned.

The controversy, however, is not over. Following a threat of legislative action to allow unlimited drilling in the PRCSF, Shell Oil Company, MDNR, and West

[1]Study supported by contributions from Federal Aid Project W-117-R, Michigan, and grants from the American Petroleum Institute, Amoco, and the Wildlife Management Institute.

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Michigan Environmental Action Council have agreed to follow the compromise outlined in 1976. This agreement was reached in December 1980, and it appears development will proceed as scheduled.

During the Corwith and Supreme Court hearings, it was necessary to rely solely on professional opinion because there was a definite lack of literature concerning the effects of hydrocarbon development on big game. The purpose of this study was to investigate the effect of hydrocarbon development on movements and distribution of elk in Michigan. This knowledge is necessary to make sound decisions regarding permission or denial of hydrocarbon development requests in the Michigan elk range.

Study Area

The area selected for intensive study was Canada Creek Ranch, a recreation and hunting club of 13,000 acres (5,265 ha). The ranch is located 13 miles (20.9 km) south of Onaway in Montmorency County in the northeast portion of Michigan's Lower Peninsula (Figure 1).

Aspen (*Populus* spp.) and upland hardwoods make up 36 and 31 percent, respectively, of the forest vegetation in this study area. Upland conifers cover 14 percent of the area and swamp conifers cover 10 percent. Open and grassland areas make up 9 percent of the study area.

Access to the study area was usually by a bridge crossing Canada Creek near the northeast corner of the ranch. However, outside gates were utilized by oil exploration crews. Although access to the ranch is limited to members of the club and their guests, traffic counters placed along entry trails indicated intensity of use was comparable to that of nearby public land.

Methods

The effects on elk of two types of hydrocarbon activity were investigated: the seismic activity and the exploratory well drillings. The seismic work which precedes the well drilling basically consisted of geophones being placed 5 yards (4.57 m) apart along what were normally north-south lines. These lines were spaced at 440 yard (400 m) intervals. The geophones received shock waves produced by dynamite exploded underground at a known distance away. The recorded data were then analyzed to determine areas most promising as well sites.

The actual well drilling activity begins with the construction of an access road and the clearing and leveling of a 2 acre (.81 ha) pad upon which the drilling rig is erected. Other than vehicle traffic on the road, all activity associated with drilling is on the pad.

The location of oil development activity was recorded each day on maps. For purposes of analysis, seismic and well activity were identified and recorded separately.

Elk were captured and marked with radio-equipped, numbered, or color-coded collars. The major objective of the marking was to identify short-term and individual movements of elk when a disturbance was encountered versus when no disturbance was present.

Elk were immobilized with propulsive syringe darts loaded with 1 cc of 20 mg succinychlorine chloride (Moran 1968). Capture techniques were adapted from

Figure 1. The Michigan elk range and location of the study area.

Flook et al. (1962). Thirteen animals were fitted with lithium-powered transmitter collars. Radio-collared animals were located daily, using an AVM Model LA-12 receiver equipped with an eight element single Yagi-type antenna (AVM Instrument Company, Champaign, Illinois). Sixteen elk were fitted with collars that were not radio equipped. These elk were observed by driving around within the study area or by observing them with radio-collared elk. Locations of animals were plotted each day on maps.

The question to be analyzed through collared elk data was whether movement patterns of elk not in close proximity to hydrocarbon activity were significantly different from movement patterns of elk exposed to hydrocarbon development activity. Control data were obtained by monitoring elk movements during periods when there was no oil development activity in the area.

Analyses of seismic activity and well-drilling activity periods were conducted separately, but both were analyzed in the same manner. All elk were initially grouped together and tests for significant differences in daily movements of disturbed and undisturbed animals were conducted. Elk were then put into similar sex and age groups. Elk in critical reproductive situations (cows with calves, bulls with harems) were also analyzed separately during those periods. Finally, several habitat variables were included to see if vegetation, topography, or escape cover might influence the movement response of elk to development activity. Univariate one-way analysis of variance was used to test for significant differences in mean daily movements.

Evaluation of habitat was necessary to determine if certain characteristics might influence elk movements. Vegetative type, stocking, and concealment value were measured and topographic category of roughness of terrain was determined.

To analyze data from collared animals, the study area was divided into a grid with units of 13.06 acres (5.29 ha). A unit of this size was determined to be the smallest locatable unit based on triangulation accuracy tests of the radio-telemetry equipment. Each of these blocks was identified with coordinates of an X and Y axis along the west and south sides, respectively, of the study area.

The location of each elk observed was identified using the coordinates of the grid. Likewise, locations of hydrocarbon development activity were also identified using coordinates. For each unit on the grid, dominant vegetative type, vegetative stocking, topography, and concealment value were identified.

Data from the collared elk were analyzed using the MTS terminal system at the University of Michigan, utilizing the MIDAS statistical analysis package.

Movement data for two and three days following hydrocarbon activity were tested for significant differences from movement data collected when no hydrocarbon activity was present. Continued increase in daily movements would be identified in this way and possible changes in elk distribution could be identified.

Change in seasonal home range was also used to indicate possible changes in elk distribution. The area included within an irregular polygon, formed by connecting the outermost radio locations for an elk, was defined as that animal's activity or seasonal range for the period of time it was monitored (Mohr 1947). The range of individual radio-collared elk was determined prior to hydrocarbon activity occurring within 656.16 yards (600 m). The next 10 locations following the day of hydrocarbon activity were then recorded to determine if abrupt changes resulted in the area being used after the activity began.

Results

Seismic exploration began on Canada Creek Ranch August 24, 1976 and continued intermittently until August 23, 1977. Actual well drilling activity began with the preparation of the first drilling pad in August 1977, and ended with removal of equipment from the fifth drilling site in June 1978.

Elk Movements

Beginning in April 1976 and ending in August 1978, 3,607 locations of 29 collared elk were determined.

Elk were located on consecutive days whenever possible in order to maximize information on movements of elk from one day to the next.

Seismic Activity

A significant (α = .01) negative correlation existed between the mean daily distance an elk moves and its proximity to seismic activity. Because elk beyond a certain point were obviously too distant to perceive the disturbance, much less respond to it, only movement data within 1,093.6 yards (1,000 m) of seismic activity were analyzed when testing for significant differences among groups. Additionally, movements within 437.4 yards (400 m) were also analyzed (Table 1).

When elk movement data were separated into sex and age groups, there was still a highly significant (α = .00) difference in mean daily movements of elk when there was no activity and when there was seismic activity. The magnitude of this difference varied from mean daily movements being 2.2 times greater for mature females to 3.4 times for disturbed mature males. Mature males, however, had lower mean daily movement distances than any other undisturbed group. Juvenile females (less than two years old) moved the greatest total distance and juveniles as a whole tended to move more than mature animals, regardless of disturbance.

Data from elk in special reproductive situations were separated from other data. Again, all mean daily movements were significantly greater when seismic activity was taking place.

Analysis of variance indicated that mean daily movements of disturbed elk were not significantly different between vegetative types. The analysis also indicated mean daily movements were not significantly different between concealment categories or between differing terrain conditions.

Movement data from two and three days following seismic disturbance were tested for significant differences from movement data collected when no seismic activity was present. There was no significant difference from normal movement distances on either the second or third day after seismic disturbance. All movements resulting from seismic activity took place within one day after the disturbance.

The seasonal home range was determined for radio-collared elk prior to seismic activity occurring within 656.16 yards (600 m). The next 10 locations were then compared to determine if abrupt changes in area being used after the encounter

Table 1. Differences between movements of elk during periods of no hydrocarbon activity and during seismic activity.

Group	Mean daily distance moved (yards)					Distance from disturbance (Yards)
	N	No Activity	*N*	Seismic Activity	Significance	
All elk	1471	463.1	75	1320.7	0.000	1093.6
	1471	463.1	34	1563.2	0.000	437.4
Males	481	434.1	18	1174.3	0.000	1093.6
	481	434.1	11	1322.4	0.000	437.4
Females	990	477.2	57	1366.8	0.000	1093.6
	990	477.2	23	1638.5	0.000	437.4

occurred. Analysis indicated there were no significant changes in elk seasonal home ranges.

Oil Well Activity

Correlation analysis indicated there was no relationship between mean daily distance moved by an elk and the distance of that elk from oil well activity. When testing for significant differences among groups of elk, movement data less than 656.16 yards (600 m), less than 874.8 yards (800 m), and less than 1,093.6 yards (1,000 m) from oil well activity were used (Table 2).

Movements of elk of different sex and age groups were analyzed when oil drilling was both present and absent. In all cases, there was no significant difference in mean daily movements of elk. The univariate one-way analysis of variance used to test for differences here is the same test used in analyzing the seismic data.

Data from elk in special reproductive situations were tested separately from other data. Again, mean daily movements were not significantly different when oil wells were present.

Analysis of variance indicated that mean daily movements were not significantly different between vegetation types. The analysis also indicated mean daily movements were not significantly different between concealment categories or between differing terrain conditions.

Movement data from two and three days following oil well activity were tested for significant differences from movement data collected when no oil well activity was present. Again, there was no significant difference from normal distances on either the second or third day after oil well activity.

The seasonal home range was determined for radio-collared elk prior to the time oil drilling activity occurred within 656.16 yards (600 m). The next 10 locations were then identified to determine if abrupt changes in the area being used resulted after the encounter. Analysis indicated there were no significant changes in elk seasonal home ranges.

Discussion

The results of this study indicate seismic activity significantly affects the movements but not the distribution of elk. Oil well activity does not significantly affect the movements nor the distribution of elk.

Table 2. Differences between movements of elk during periods of no hydrocarbon activity and during oil well drilling activity.

	Mean daily distance moved (yards)					Distance from distur- bance (Yards)
Group	*N*	No activity	*N*	Oil well activity	Signifi- cance	
All elk	1471	463.1	45	406.4	N/S	656.2
All elk	1471	463.1	84	385.7	N/S	874.8
All elk	1471	463.1	101	373.7	N/S	1093.6
Males	481	434.1	17	365.6	N/S	656.2
Females	990	477.2	28	431.1	N/S	656.2

The daily movements of undisturbed elk in Michigan are similar to movements of elk found in other states. George et al. (1973) reported that daily movements of elk in Pennsylvania were usually not more than several hundred yards. Harper (1971) reported that the beginning and end points of daily movements of Roosevelt elk may only be 300 to 400 yards (275 to 366 m) apart. Data collected in this study indicate the mean daily movement of an undisturbed Michigan elk is 463.25 yards (423.6 m) straight line distance.

Seismic Activity

Of the two types of hydrocarbon activity investigated, seismic activity is the one of most concern in relation to its effect on elk movements. The distances moved by elk were normally inverse to the distance from seismic activity. The increase in mean distance moved by disturbed elk was 979 yards (895 m). Stehn (1973) found increases in movements of elk startled by human disturbance to range from 704 yards (643.7 m) to 2,816 yards (2,575 m) with a mean of 1,584 yards (1,448 m).

The implications of elk movements increasing is normally not serious if elk were not removed from suitable habitat. Within the study area, even the maximum daily movements of disturbed elk did not place them outside excellent elk range. However, in other parts of the Michigan range, in habitat of marginal quality, or in that part of the range bordering agricultural or residential areas, sudden increases in movements could place the elk in critical situations.

The most serious implications of an increase in mean daily elk movements may concern those animals in special reproductive situations. During the fall rut, the establishment and maintenance of dominance is accomplished by the herd bull through a continual series of encounters and challenges. When daily movements are more than doubled, the normal rut activities are liable to be disrupted. If the movement results in a breakup of the harem, the social order of the established dominance hierarchy could be upset.

The other situation in which an increase in mean daily movements could be serious is during the calving period. Harper (1971) reported that cows have favored calving sites, usually located on the warmer exposures and associated with areas of gentle terrain. If the extreme movement resulting from seismic activity should drive a cow near parturition to an area not favored for calving, the chance of survival of the calf might be reduced.

Although elk movements significantly increased in response to seismic activity, the range used did not significantly change. The movement response took place immediately following disturbance and normal activity patterns were followed the day after the movement response. Stehn (1973) reported the longest movement of disturbed elk took place within a one-hour period after the disturbance. In this study the elk usually stayed within the seasonal home range, and when they did go beyond the boundary, they usually stayed within 656.2 yards (600 m) of the previously established range.

Oil Well Activity

Actual oil well activity did not affect the movements nor distribution of the elk monitored in this study. Contrary to the behavior of elk in close proximity to seismic activity, the mean daily distance moved by elk within 656.2 yards (600 m) of an oil drilling rig was not significantly different from the movements of elk when there is no hydrocarbon activity present.

Of primary concern was the reason why seismic activity so drastically affected elk movements while oil well activity had no significant effect. Apparently the explanation lies in the nature of the activities. Seismic activity is a constantly moving operation and the inability of the elk to predict the course of this movement prompts one of two responses. The disturbance may cause the elk to put a great distance between itself and the possible danger. Or, in some cases, elk have a tendency to stare at the disturbance, trying to identify it rather than fleeing immediately (Murie 1951). Eventually, the disturbance reaches a point close enough to the elk that it perceives it as possible danger and takes flight. At any rate, the movement of seismic activity through the elk's habitat is the characteristic that causes the flight response.

The oil well activity is stationary and all activity is confined to the 2-acre (.81 ha) well pad and the access road. Any elk utilizing the area advance closer to the well activity only when they have become accustomed to the activity and do not perceive danger. Because the oil well activity is stationary, the only way the elk can be disturbed is by moving closer to the pad. The elk, of course, will not do this until curiosity or their becoming accustomed to the activity allows them to. In either case, no increase in mean daily movements would occur. A study by Hershey and Leege (1976) in north central Idaho found that elk as close as 328 yards (300 m) did not move away from low intensity, short-term logging disturbance.

The purpose of this study was to investigate the effect of hydrocarbon development activity on elk movements and distribution. Other variable aspects of each particular situation must be considered before the total impact of a development program can be measured. The intensity of development could be a variable that, under some circumstances, could elicit responses more extreme than those recorded in this study. In this study, elk response to pipelines was not monitored. The positive and negative aspects of pipeline corridors exemplifies another facet of oil development which should be investigated.

Additionally, elk are only one part of the mammalian fauna. Other species, possibly more sensitive than elk to human activity, should be considered when determining hydrocarbon development guidelines. When all aspects, from aesthetic values to economic benefits, are weighed, hopefully the entire wildlife community will receive adequate consideration in the decision-making process.

Acknowledgments

This report is part of a dissertation submitted in fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Michigan. I wish to thank my dissertation committee for their guidance: Dr. Archibald B. Cowan, Dr. Dale R. McCullough, Dr. Donald F. Eschman, Dr. Alvin L. Jensen, and Dr. Ralph I. Blouch. I would also like to thank Mr. Richard R. Moran and Mr. Robert Doepker from the Michigan Department of Natural Resources for their assistance.

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Problems Facing Wildlife Habitat Management on Canadian Forest Lands

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Introduction

As Boyd (1979) recognized in a paper on wildlife management in Canada delivered to this conference two years ago, it is ironic that agencies that have no direct responsibility for wildlife often have more influence over wildlife than those that have. This situation is well illustrated in Canada, where provincial forestry agencies influence wildlife habitat over vast areas, far more than the influence of the responsible wildlife agencies. Boyd observed that it may be more important for wildlife agencies to influence the actions of other resource management agencies than to manage wildlife directly, and this paper addresses itself to that proposition.

The importance of forest management practices to wildlife has long been recognized (Leopold 1948), as have the opportunities for increasing wildlife populations by suitable forest management (Giles 1962). Although some Canadians have been aware of these potentials (Schierbeck 1931, Edwards et al. 1956, Pimlott et al. 1971), wildlife has been given minimal consideration in the management of Canadian forests. Recently increased public awareness of environmental matters and the example of intensified multiple-use management of forests in the United States have caused Canadian biologists, foresters and the general public to look seriously at the state of integration of wildlife and forest management. Major studies of the impact of forest harvesting on wildlife and other environmental factors have been undertaken in some provinces (e.g., Schultz and Co. 1973, in Alberta), but they have not led to much change in the status quo. The future is likely to bring rapid reduction of Canada's uncut forest in formerly remote areas, more intensive utilization of managed forests, greater use of mechanical and chemical treatments in silviculture, and an increasing backlog of inadequately stocked cutover lands.

Concern among wildlife administrators about the lack of integration of forestry and wildlife management led to our appointment to investigate the situation for the Federal-Provincial Wildlife Conference (an annual meeting of Canadian wildlife administrators). The purpose of our investigation was to evaluate the integration of wildlife considerations in forest management on forest lands in Canada, to identify problems inhibiting better wildlife management, and to propose general solutions that would serve to focus further study by provincial wildlife agencies. This paper presents a summary of our findings. They are based largely on views expressed to us by provincial employees of wildlife and forestry agencies.

The Canadian Forests and Forest Products Industry

Forests occupy a vast area in Canada, covering more than half the land area of the 10 provinces or more than 725 million acres (290 million ha) (Reed 1979). While that land area is approximately equal in size to the forested area of the 48 contiguous states (Clawson 1979), it supports a forest products industry that plays a far greater role in the nation's economy than does its counterpart in the U.S.A. The forest products industry contributes approximately 11 percent of Canada's G.N.P., compared to about 2 percent for the U.S.A. (W. Ondro, pers. comm.). Canadian forest industries employ directly over 300,000 workers or 3.2 percent of employed Canadians. A total of over 1,500,000 jobs (16 percent of employed Canadians) depend on the existence of the forest industry. Canada's forest industries produce products worth $17 billion annually. Those products contribute 20 percent of Canada's exports and 30 percent of the world trade in forest products (Reed 1979).

Over 4 million acres (1.6 million ha) are logged annually to supply the forest industry. Fire suppression and insect control affect ecological conditions on much forest land, and site preparation, thinning, fertilization, and planting of monocultures are small but growing impacts. One may safely conclude that politically, economically, and ecologically, the forest products industry is a large and compelling force in Canada.

Canada shares major forest regions with the northern United States. In the west, the productive coastal evergreen rain forest continues north into Canada and grades into the coastal forests of southeast Alaska (Rowe 1972). In the east the deciduous oak-hickory (*Quercus-Carya*) forest occurs (where not eliminated by agriculture) in southern Ontario, while the hemlock-northern hardwood (*Tsuga-Acer-Betula-Fagus*) association with white pine (*Pinus strobus*) occupies much of central Ontario, southern Quebec and most of New Brunswick, Nova Scotia and Prince Edward Island. However, the greatest forest region of Canada is the boreal spruce-fir-jackpine-poplar (*Picea-Abies-Pinus banksiana-Populus*) forest stretching from Newfoundland to northern British Columbia and the southern Yukon and Northwest Territories. Canada shares the circumpolar boreal with interior Alaska, the Soviet Union and Scandinavia.

Canadian forests are largely in public ownership. Provincial governments hold approximately 76 percent of forest land while the federal government holds another 18 percent (mostly in inaccessible northern regions). Only 6 percent is privately owned (Canadian Forestry Service 1978), and this occurs mostly in the southern and settled regions of eastern Canada. It is obvious that, on the Canadian scene, the management of provincial lands has the greatest potential impact on wildlife. We have therefore directed our attention in this paper to provincial—rather than to federal or private—forest land management.

Canadian Wildlife

As with forests, Canada shares much of its fauna with the northern states. However, many species and some management goals do differ. For example, the most important species in terms of public profile and economic importance are the three ungulate game species, the moose (*Alces alces*), deer (*Odocoileus* spp.), and elk (*Cervus elaphus*). The moose is found in every province and territory but Prince Edward Island. The caribou (*Rangifer tarandus*) also occurs sparsely over

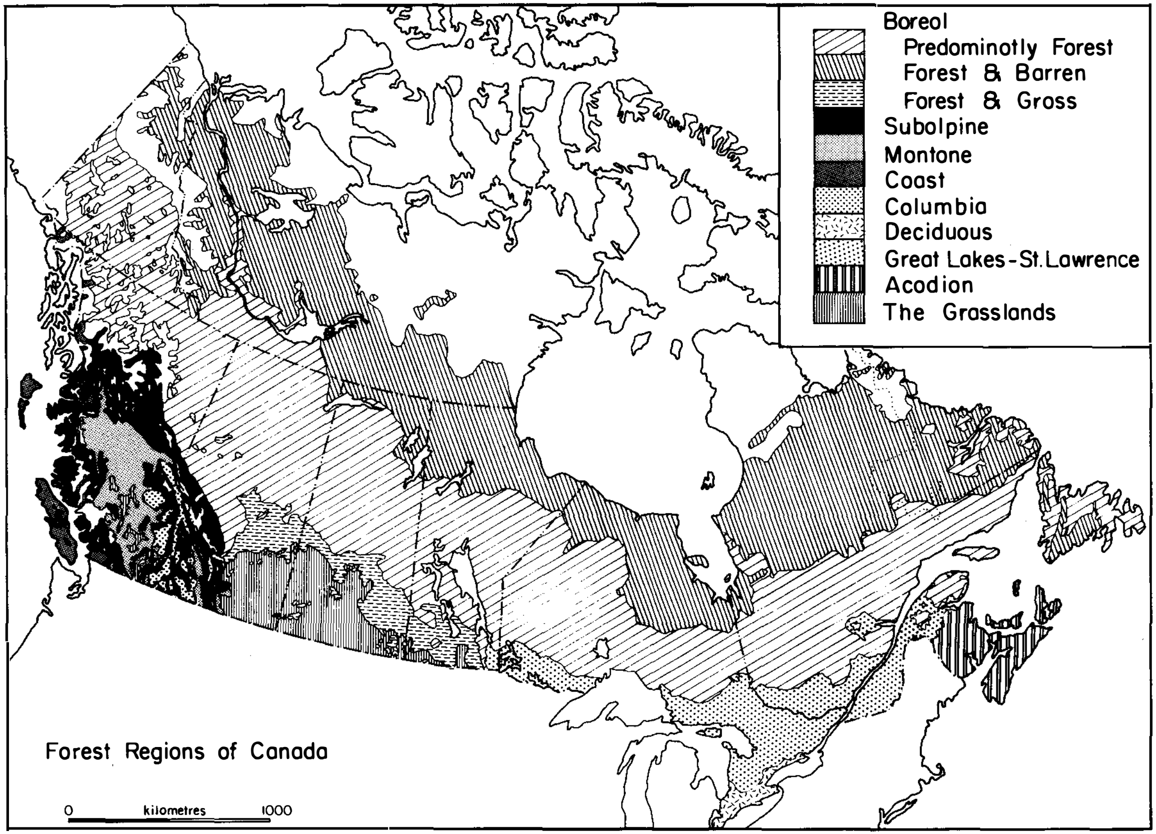

Figure 1. Forest regions of Canada (after Rowe 1972).

vast portions of the boreal forest. The black bear (*Ursus americanus*) is universally distributed throughout all forested areas except on Prince Edward Island, while white-tailed deer (*Odocoileus virginianus*) is the most important game species of the hemlock-northern hardwood region and the southern fringe of the boreal forest west to the Rocky Mountains. Elk, mule deer (*Odocoileus hemionus*) and antelope (*Antilocapra americana*) are locally important in the western provinces while the black-tailed deer is the principal game animal in the forest of the British Columbia coast. As outlined by Bossenmaier (1979), management of game species and other wildlife, with the exception of most migratory birds, falls under the jurisdiction of the provinces and territories.

Policy Problems

Lack of Goal for an Acceptable Minimum Wildlife Community on Forest Lands

The forest manager has a goal to produce wood fiber from the land, based to a large extent on the potential productivity of the land itself. Target yields are set for each cut and stocking targets are identified for regenerating stands. The terms established for timber leases taken out by private companies usually state that the current productivity of the limits must be maintained. They may also provide incentives for increasing productivity (I.C.M. Place, pers. comm.). Companies may modify cutting practices to insure that stocking levels required by long-term management agreements are attained. Even though the actual production goals for given tracts of forest are usually set only at the local level by the management forester, the fact remains that the concepts of a timber production goal and an acceptable residual stocking are entrenched in forest management policy and are the bases for forest management decisions. Rarely in Canada do these concepts extend to include other components or "products" of the forest ecosystem.

The lack of policy guidelines for the minimum wildlife community that should persist during and following forestry operations puts wildlife managers at a disadvantage in competing with forestry interests for the use of a given tract. Management for fiber products receives more status because its goals for production are more clearly definable in classical economic terms.

In some provinces the wildlife biologist may have targets for the production of some game or furbearing wildlife on forest lands, but those targets are usually more difficult to quantify and less formal than forestry goals. They are not set down as official policy and therefore do not *require* the land manager (usually a forester) to consider them in management plans.

In many parts of the boreal forest, foresters are having difficulty in re-establishing commercially viable forests on lands that have been cut. The concern created by this so-called "regeneration gap" often focuses attention solely on the timber resource and diverts attention from any of the other resources produced.

Steps Toward a Solution

Successful integration of wildlife into forest management planning requires that wildlife be officially recognized as a quantifiable product of forest land. In addition, standards for a minimum wildlife community must be established for managed forests. Compared to forest vegetation, wildlife is subject to greater fluctuation, is more difficult to census, and is less well understood scientifically. Consequently, it is more difficult to define the forest wildlife community and the effects of forestry practices on it. However, recognition of the forest as an ecosystem with interdependent floral and faunal communities is a prerequisite to the development of forest management that creates minimum disruption.

The capability of forest lands to support wildlife must be assessed and goals for the production of wildlife based on that capability must be identified. A minimum wildlife community must be defined on the basis of the levels of species diversity, density, and distribution that are necessary to retain the basic integrity of the forest wildlife community. Each jurisdiction will have to decide on the degree of change in wildlife populations that it considers acceptable. Before such decisions can be made, more research into the biology of forest wildlife communities will be required to identify key (indicator) species whose retention is critical and the minimum densities at which their populations can persist. Those decisions can relate to ecological, aesthetic and/or economic objectives and rationales. In most places, research will be required to establish the capability of the local forests to produce wildlife and on the habitat characteristics essential to production of the species and densities desired. Goals and objectives should be adjusted in the light of the results of on-going research.

Lack of Policy Requiring Wildlife to Be Considered in Forest Management Plans

In Canada, as in many states, government departments charged with the management or conservation of natural resources have been divided into independent agencies each responsible for only one resource; e.g. water, timber, recreation, wildlife. Each is given a mandate to manage that one resource, and any side effects on other resources are given scant attention. It is increasingly evident that this approach has usually resulted in mediocre management of even the dominant resource(s) (e.g. timber) and is particularly hard on those of apparently lesser status or "value" (e.g. wildlife).

As D. Fraser (pers. comm.) pointed out at a recent conference on the effects of herbicides on the boreal ecosystem, many jurisdictions in Canada have attempted to manage different components of the forest ecosystem separately. He stated that:

> We have the forestry component with its own policies, objectives and programmes, its own staff and research group; and we have the wildlife component with its separate objectives, programmes, staff, and separate research group. Perhaps the worst result of this split is the tunnel-vision it produces in the staff. Many wildlife biologists and foresters seem to feel that it is legitimate and even possible to manage one component of the ecosystem in isolation from the others.

In most Canadian provinces, the responsibility for management of forest lands lies with the forestry agency, and through its auspices large tracts of Crown land are leased to private industry for timber production. While it is true that the forestry agency's official policy may include the goal of "multiple-use," the fact is that emphasis goes to the timber resource, and other uses like recreation or wildlife production receive attention only where they are of spectacular proportions or where they do not conflict with forestry operations. Thus the problem is not *lack* of policy: the concept of multiple use is already acknowledged. The problem lies with practical *application* of the policy and the great discretionary power over the management of the land that has been given to the forestry agencies.

In some jurisdictions there is reasonably effective cooperation between foresters and wildlife biologists on multiple use of land. However, these arrangements are generally informal. The extent to which foresters recognize the needs of wildlife on forest land often depends to the extent to which foresters are willing to listen to their wildlife colleagues. Few provinces specify that foresters, as the land managers, *must* produce wildlife from the Crown land or that modifications to procedures for timber management must be made to benefit wildlife.

Federal grants-in-aid to provinces for forest or agricultural development have been identified as creating major problems in multiple resource management. These monetary grants are intended to increase employment and speed economic development through exploitation of a single economic resource. Examples are the clearing of marginal land for agriculture or the silvicultural treatments to improve forest regeneration. The grants specify that the province must spend the money to produce the specified product, although the province has the option of spending its own money on other aspects. Federally subsidized drainage of wetlands for agriculture is a classic example. Here, wetlands of high value to wildlife are sometimes destroyed while gains to agriculture are often marginal. A parallel situation exists in forestry, when harvesting or other operations of low economic viability are subsidized by federal funds to benefit the local economy. Wildlife or recreational options are not considered because they appear to have lower economic promise.

Steps Toward a Solution

Provincial policies that *require* wildlife to be considered in forest management plans, leaving no option, would have two beneficial effects. The first would be to force land managers in districts where inadequate attention is paid to wildlife to cooperate with wildlife managers in land management planning, making provision for wildlife where benefits can be justified. Secondly, they would force the land manager to make and adhere to forest management plans that are suitable for examination by the proponents of other interests in the land—in this case wildlife. They would also reduce the likelihood that the plans approved by the wildlife biologist would be later changed by the forester without consultation.

Another approach would be to broaden the jurisdiction for the agency managing forest land to include wildlife and other resources. If existing forestry and wildlife agencies had integrated responsibility for management of forest lands, there would have to be more cooperation and more attention to wildlife needs. In some provinces agencies charged with timber management are funded solely for that purpose and cannot divert any of their budgets to benefit other resources.

Lack of Policy Requiring Integrated Inventory of All Resources on Forest Lands

In many provinces the various resources on a forest tract are inventoried separately, that is, forestry technicians cover commercial tree products, wildlife biologists cover wildlife habitat, etc. Wildlife biologists have often not had the manpower and the staff at their call to equal the speed or depth of the forestry inventory. As a result they have been unable to make sound proposals for modifications to forest management practices necessary to benefit wildlife. In many cases the foresters have unilaterally conducted inventories and prepared management plans for tracts of land. Wildlife biologists would then be asked to comment on the plans without adequate advance notice or manpower to conduct an equivalent inventory. Consequently, biologists had the choice of proposing dogmatic modifications based on conventional wisdom (e.g. limiting size of clearcuts) that may or may not be appropriate in the locality, or to propose no modifications at all.

Steps Toward a Solution

It should be feasible to organize single, integrated inventories of all resources on forest lands by teams representing the various natural resource disciplines. Staff of wildlife agencies could be assigned to cooperate in the conduct of forest inventories, or inventory teams that currently gather only forestry-related information could be requested to include information of value to the wildlife biologist. Forest inventory staff can collect much information on wildlife habitat at little extra cost during forestry surveys. Assessment of the information, however, would require wildlife biologists with adequate funding. The Canada Land Inventory (CLI) was an important Canadian first step toward integrated resource inventories, but it was conducted on too broad a scale to be useful for operational planning. From the CLI have grown improved concepts of biophysical inventories which hold great promise for creation of integrated data bases for future planning.

Technical Problems

Lack of Fundamental Knowledge of Habitat Requirements

This problem has two aspects: lack of autecological data on individual species and lack of understanding of how forest ecosystems function. Data on individual species provide the building blocks for understanding how an ecosystem functions and for appreciation of the impacts caused by changes in the system. Ecosystem studies provide the additional advantage of establishing the extent to which species can be grouped in feeding guilds, life forms, etc. to simplify management planning. Much useful work on animal habitat requirements and analysis of forest systems is in progress in the United States (much of it conducted or funded by the U.S. Forest Service). Canadian conditions, however, differ from those of most of the U.S. Variations in winter weather more frequently override habitat quality as a factor controlling populations of resident wildlife in the short term. Our forests, especially in the Boreal Region, are of simpler composition. Both fauna and flora consist of fewer species. Fire has been a pervasive influence since the Pleistocene. All these factors contribute to making Canadian forest ecosystems less stable in the short term and favorable to those species having broad ecological amplitude that can tolerate much environmental change and respond quickly to favorable conditions. It must also be appreciated that many wildlife species find the northern boundary of their ranges in Canada and may be existing in a marginal situation in this country. They are thus acutely sensitive to altered conditions of life, of which habitat conditions are among the most important.

Steps Toward a Solution

An acceptable level of environmental management requires more thorough ecological baseline data than we at present possess. Two lines of approach should be followed. The most important involves long-term monitoring studies of habitat, climate and animal populations. Most traditional investigations have been of too short duration to provide complete data over a range of conditions where climatic conditions fluctuate as they do in Canada. Such studies must of course be carefully designed to provide the most important systems data for the least cost. They can best be carried out as part of the program of larger research organizations where continuity of programs can be assured even though personnel may change.

There is certainly a place and a need for short-term in-depth studies of individual species in relation to habitat use. Such studies should include non-game as well as game species. Description of habitat in any forestry-wildlife study should follow traditional forestry techniques and terminology insofar as possible. Additional research on techniques for habitat evaluation is also required.

Lack of Knowledge of the Effects of Specific Forestry Practices

Such practices include various timber harvesting methods, regeneration techniques and stand-tending procedures like thinning. Measures for forest protection are also important to wildlife. For instance, fire suppression has probably influenced habitat conditions on more acres of land in Canada than anything that modern technological man has done. Spraying to control insects has stimulated some of the greatest controversies relating to wildlife in the forest. The problems of impact exist on two geographic levels: the effect on the use by animals of the treated areas themselves, and the response of animal populations on larger areas, such as watersheds, within which forest management activities take place.

Steps Toward a Solution

Two lines of approach to these problems of prediction seem relevant. The first is to conduct carefully designed applied research to evaluate responses to treatments on the two geographic levels mentioned above. Such studies may require that special treatments be made for research but may often be more cheaply conducted by taking advantage of situations that occur fortuitously in the course of forestry operations with, perhaps, some minor modifications.

Data obtained from applied studies can be combined with information from the existing literature for evaluation through modelling wildlife conditions resulting from various forest management systems. Computer simulation provides a powerful tool for arriving at predictions of impacts and should be systematically evaluated and refined.

Existing Information of the Relation of Forest Management to Wildlife Is Not in a Readily-usable Form

Most professions have produced comprehensive texts, manuals and local guidelines for the guidance of field practitioners. The young profession of wildlife management is still deficient in that regard. Management of forests for wildlife habitat is a "no man's land" between the wildlife and forestry professions, adding to the problem of condensing existing information. A recent U.S. Forest Service book (Thomas 1979) is a helpful contribution toward filling this lack of assembled information. It will be most valuable to Canadians, however, as a source book for useful concepts. We need guides to practices applicable to the ecological and institutional situations existing locally in Canada.

Steps Toward a Solution

Existing information can be brought together on two levels. General reviews of literature on Canadian conditions and of the world literature (Russian and Scandinavian as well as American) relevant to Canada can give overall guidance to the development of local practice guidelines. Such guidelines should be supported by manuals describing "how to do it" and "how not to do it" in the interest of local wildlife. Preparation of such manuals and guidelines for integration of wildlife considerations in forest management presupposes the existence of field people who understand both forest and wildlife management, and who have a positive mandate for integrated resource management.

Lack of Techniques for Valuation of the Wildlife Resource

Comparison of wildlife values with those for timber is difficult. Wildlife obviously has a commercial value although this is partly obscured in Canada because almost no income from wildlife can be realized by forestry interests. Also, those interests must often bear costs related to public exploitation of wildlife. Wildlife values as part of a healthy environment transcend commercial values but have proved difficult to quantify. Ingenious systems for evaluating such intangibles exist but usually require acceptance of many assumptions of a sociological nature.

Steps Toward a Solution

New conceptual approaches to the valuation of intangibles are badly needed. A simple approach to setting wildlife values, however, could be explored if minimum standards can be set for adequate faunal communities in managed forests. In that case the costs of modified forestry practices needed to ensure those standards can be determined. "Value" of wildlife on an area would thus be the cost of maintaining it. Policy decisions could then be made provincially as to who should bear those costs. Assigning costs for expensive modifications to forest management practices for the benefit of wildlife would provide great incentive to ensure that the modifications were based on more than assumptions or conventional wisdom.

To arrive at reasonable cost estimates, applied research on logging and other forest management costs under various courses of action are required. In many cases there are scattered examples of cooperative forestry-wildlife projects than can provide useful data (for example, management programs in deer yards in eastern provinces). Costs also exist for *not* including certain areas in forest management due to wildlife considerations and can be calculated and included in evaluations.

Conclusions

In our opinion, the major reason wildlife has not been widely considered in forest management is not that foresters have deliberately excluded it, but that they saw no good reason to include it. That attitude extends to the public at large, to politicians, bureaucrats, and legislators. Why produce wildlife when there is no appreciation of wildlife values or benefits? The situation in Canada now is analogous to that which existed in the U.S. when forest managers were not very concerned with wildlife because, as Thomas (1979) states, "The law did not require it. The public did not demand it. Politics did not compel it."

In Canada, where forests constitute the major traditional economic resource over vast areas, it is going to be very difficult to change the *status quo* without first creating a basic change in public attitude. Before we can accomplish that change, we will need to do several things:

1. show the extent to which forestry affects or competes with wildlife (e.g. does it *really* have detrimental impacts? Can proper management *really* increase numbers and diversity of wildlife?);
2. identify the wildlife values or benefits that are impaired by existing forest management procedures or could be enhanced by modified procedures;
3. set forth sound social, economic and scientific reasons why changes in forest management practices should be made to achieve certain benefits for wildlife;
4. demonstrate that all reasonable means of managing wildlife other than habitat modification have been considered (for example, the control of hunters or predators);
5. explain these reasons to the public.

It is step no. 5 that will be the most difficult. As described concisely by the Committee of Canadian Concerns (1980), the public wildlife constituency in Canada is relatively small, and certain aspects of the Canadian systems of law and government encumber the process of strengthening environmental management. The diffuse nature of the wildlife-forestry relationship and fragmentation of jurisdiction further inhibit mobilization of public concern to enforce needed policy changes. Once policy changes have occurred, however, most technological problems can be solved through increased support for research and more intensive application of the findings.

In the near future, draft forest management agreements in at least one province are going to be opened to wider public examination before they become final. This could be the beginning of more effective public input to assessment of the values of *all* benefits to be derived from forest lands.

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Management of Prairie Potholes and National Wildlife Refuge System Lands

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I am pleased to have the opportunity to discuss management of the prairie potholes and other refuge lands with you this afternoon. Most of the pothole region is in Canada. An important portion is in the United States—principally in the Dakotas, but it includes portions of Montana and Minnesota. Aside from Alaska, this is by far the best waterfowl production area in the United States. It is extremely important to us. Yet a very small amount of the land in the pothole region is in public ownership. It is precisely because so few lands are in public ownership that they are so important.

But, before proceeding, let's put the prairie pothole situation in proper perspective by looking at the total public land picture in the United States. How much public land is there? Who controls it, and how much is devoted to wildlife?

Figure 1 shows the distribution of federally controlled land in the United States. A glance at this map is sufficient to predict which States will probably be most active in the Sagebrush Rebellion.

Figure 2 gives us a better perspective on public and private land ownership. Notice that the actual percentage of Federal public lands in the United States is 34 percent.

Figure 3 shows the breakdown of public lands by Federal agency. The U.S. Fish and Wildlife Service controls 11.5 percent of Federal land.

In Figure 4 we see the Fish and Wildlife Service lands again, expressed this time as a percentage of the total public land and private land in the United States. The Fish and Wildlife Service controls 3.9 percent of the total United States land surface. It is important to observe, however, that 86 percent of the land represented by this small wedge is located in Alaska. In the 48 contiguous States, the Fish and Wildlife Service controls a very small amount of very important wildlife habitat.

The large jump in the number of acres controlled by the Service in 1980 was, of course, a result of the Alaska Lands Bill. This change, involving 40 million acres (16.2 million ha), was not an increase in the amount of public lands, but rather a redesignation of the use of existing public lands. These lands already were producing wildlife. Their designation as wildlife refuges only placed a higher priority on their continued management for wildlife.

Figure 5 shows the geographic distribution of lands administered by the Fish and Wildlife Service. Most of the tracts are too small to show up on a national map and therefore are depicted by dots.

Let's look next at Region 6 of the Fish and Wildlife Service which includes the Dakotas, Nebraska, Kansas, Montana, Colorado, Wyoming, and Utah. Of the total land in this Region, only two-thirds of one percent is under the Fish and Wildlife Service's control. As shown in Figure 6, roughly one-third of this is big game range which is mostly grassland. Another quarter is devoted to other species—mostly waterfowl. The remaining portion consists of small parcels of a few dozen to a few hundred acres each. These are scattered potholes and wetlands

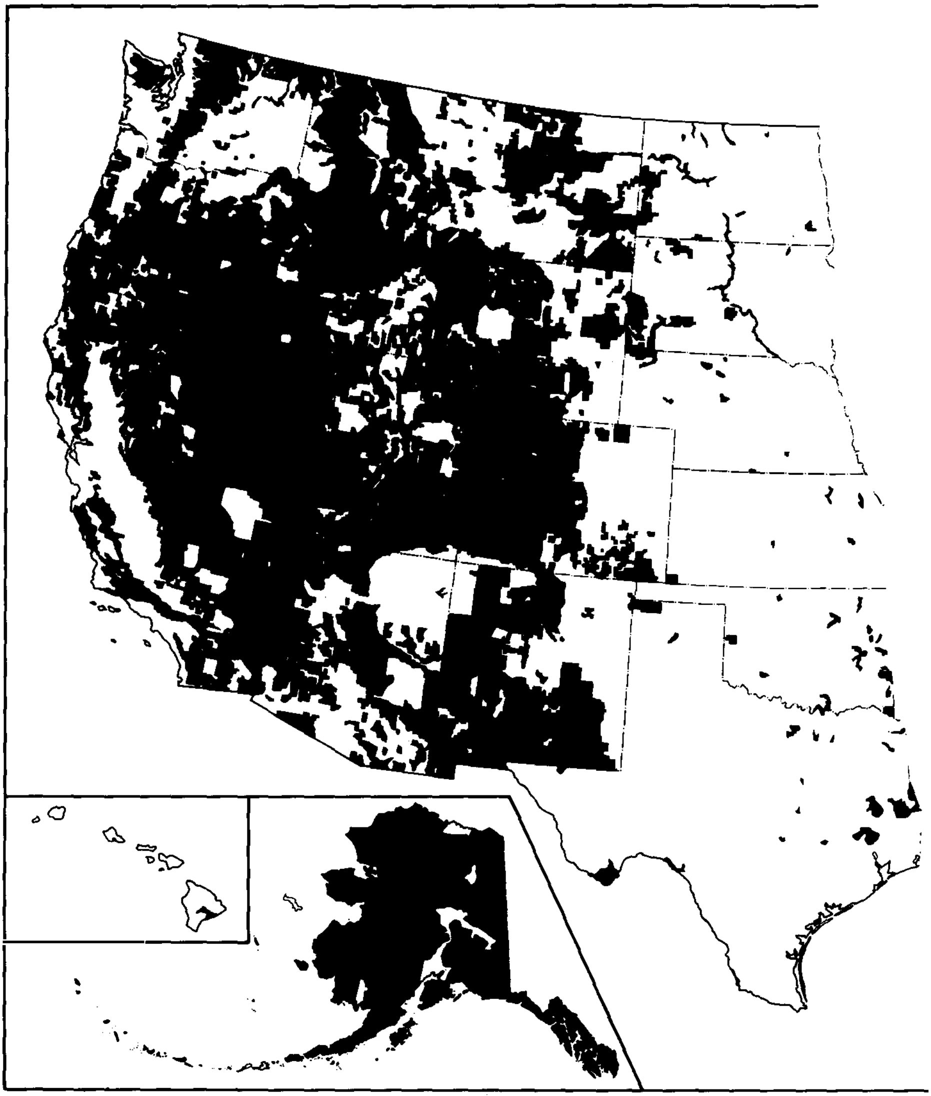
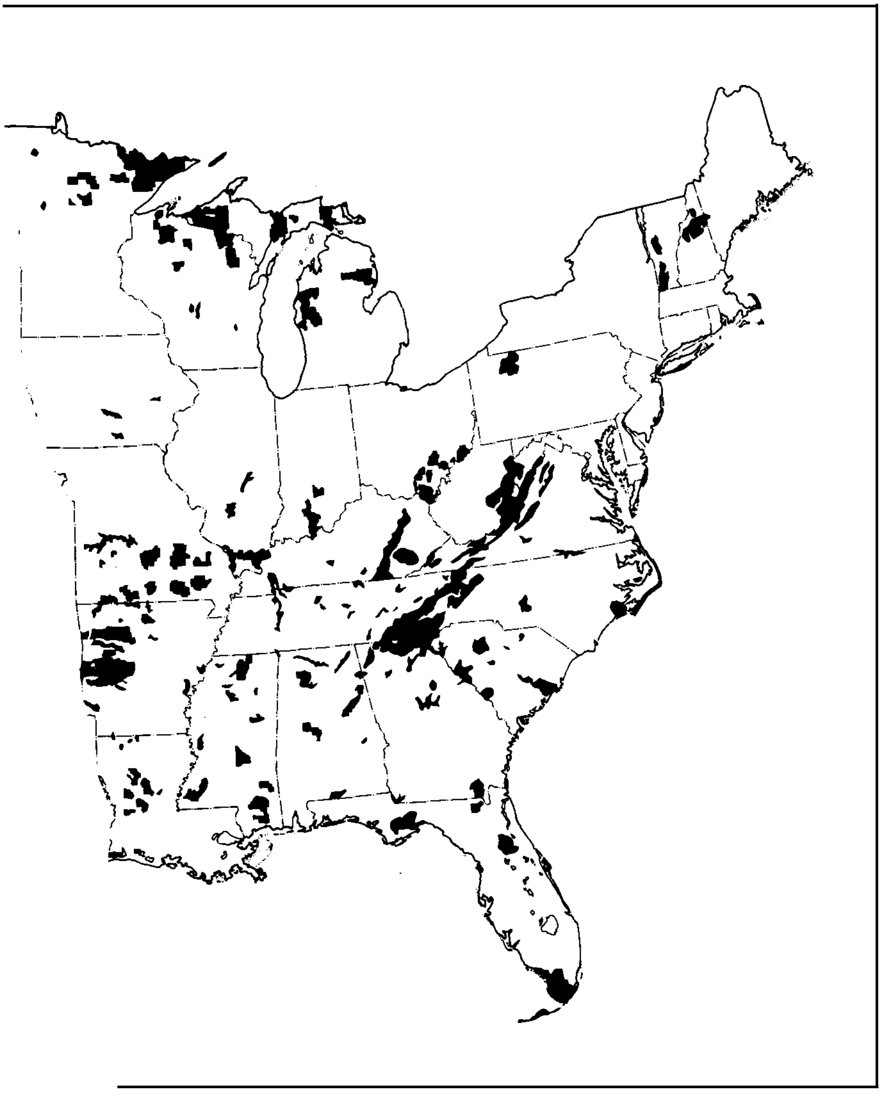


Figure 1. Distribution of federally-controlled land in the United States, excluding Indian reservations and military installations.



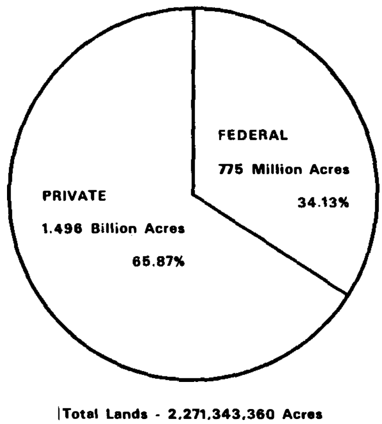


Figure 2. Ownership of land in the United States.

which are safeguarded for waterfowl production. About 31.5 percent is owned in fee title and about 68.5 percent is easements.

Beginning in about 1956, the Service started using easements to a greater degree to protect wildlife habitats. In 1961, the Small Wetlands Acquisition Program started. Through the Wetlands Loan Act, Service acquisition by fee and easement was accelerated. The easements are intended to achieve habitat preservation objectives without causing all the socio-economic problems associated with fee purchases. In the face of growing opposition to land purchases, the use of easements has increased while fee acquisitions have decreased. In recent years opposition has increased even to easement acquisitions for wildlife purposes. There is

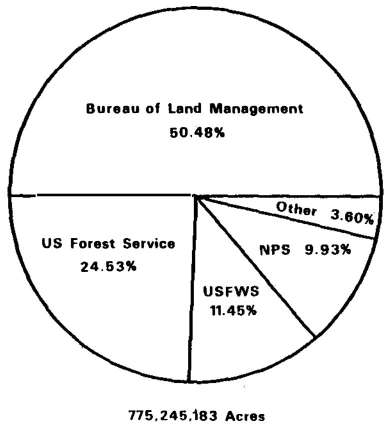


Figure 3. Breakdown (by agency) of Federal lands.

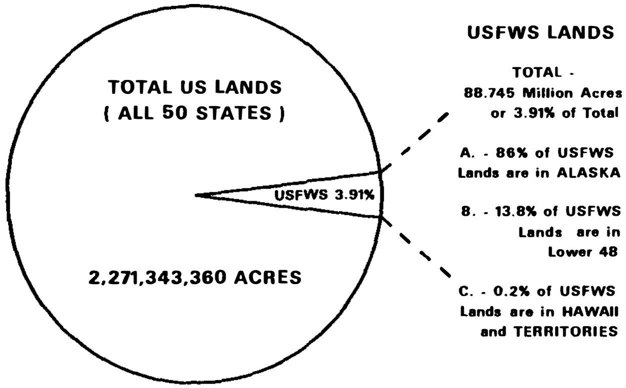


Figure 4. Percentage of all U.S. lands controlled by the U.S. Fish and Wildlife Service.

a growing number of people who oppose setting aside any more lands for wildlife. They would prefer to stop all land acquisition by wildlife agencies. Short of that, they would prefer to limit wildlife agencies to the lesser control provided by easements. But recently there is even growing opposition to perpetual easements with pressure to limit the length of easements to 20 years, or termination upon sale of the property or death of the owner.

There are several other factors to consider concerning the use of easements. Substantial ongoing costs are required to enforce easements. Fish and Wildlife employees must continue to monitor the landowner's use of the land to ensure that the conditions of the easement are not violated and to take legal action when violations occur.

Landowners sometimes fail to tell those who buy their land about easements that have been sold to the Fish and Wildlife Service. When a new owner discovers the easement, he frequently is irate that the land cannot be used with complete freedom. The displeasure of the new owner usually focuses on the Fish and Wildlife Service rather than the person who sold the land without disclosing the easement, or his own attorney who failed to point out the easement. An easement is often a source of continuing irritation to the primary owner of the land. So the temptation is strong for him to try to find ways to get around the easement restrictions. Your question is, "So what?" Have those lands made a difference in maintaining wildlife populations at desired levels?

In 1937, Aransas National Wildlife Refuge was established to prevent further damage to critical winter habitat of the whooping crane. Eight other Federal refuges plus several State and Canadian refuges serve as migration stops for the Aransas flock. With those lands in public ownership, the flock grew from less than 20 birds to nearly 80 birds. Without public control of those lands, the great white bird probably would have perished.

There are other success stories. Protection of nest sites on Loxahatchee National Wildlife Refuge seems to be swinging the balance in favor of the Florida Everglades Kite. Creation of a Federal refuge for the key deer helped that species increase from a few dozen animals to the present population of three to four hundred.

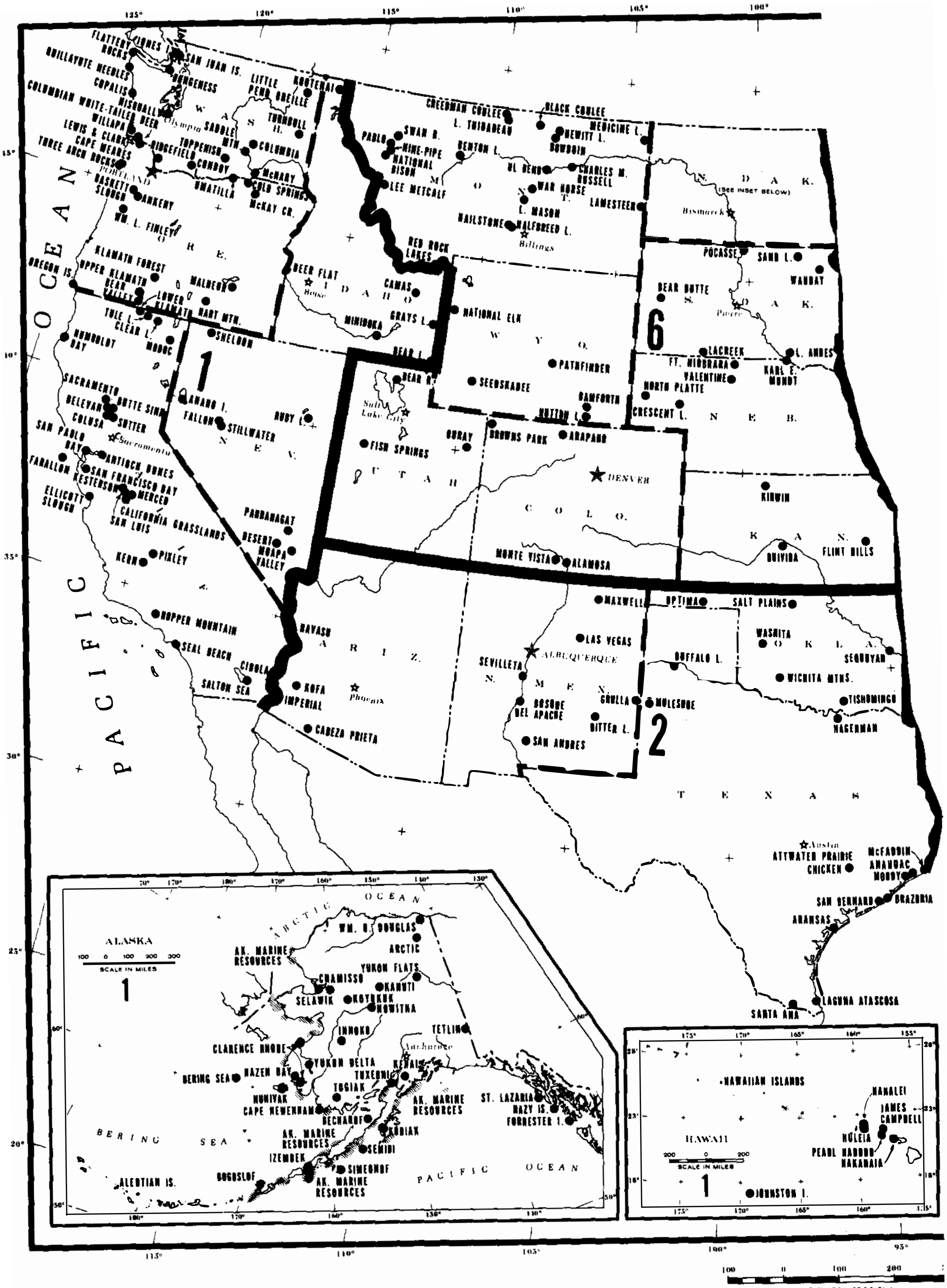
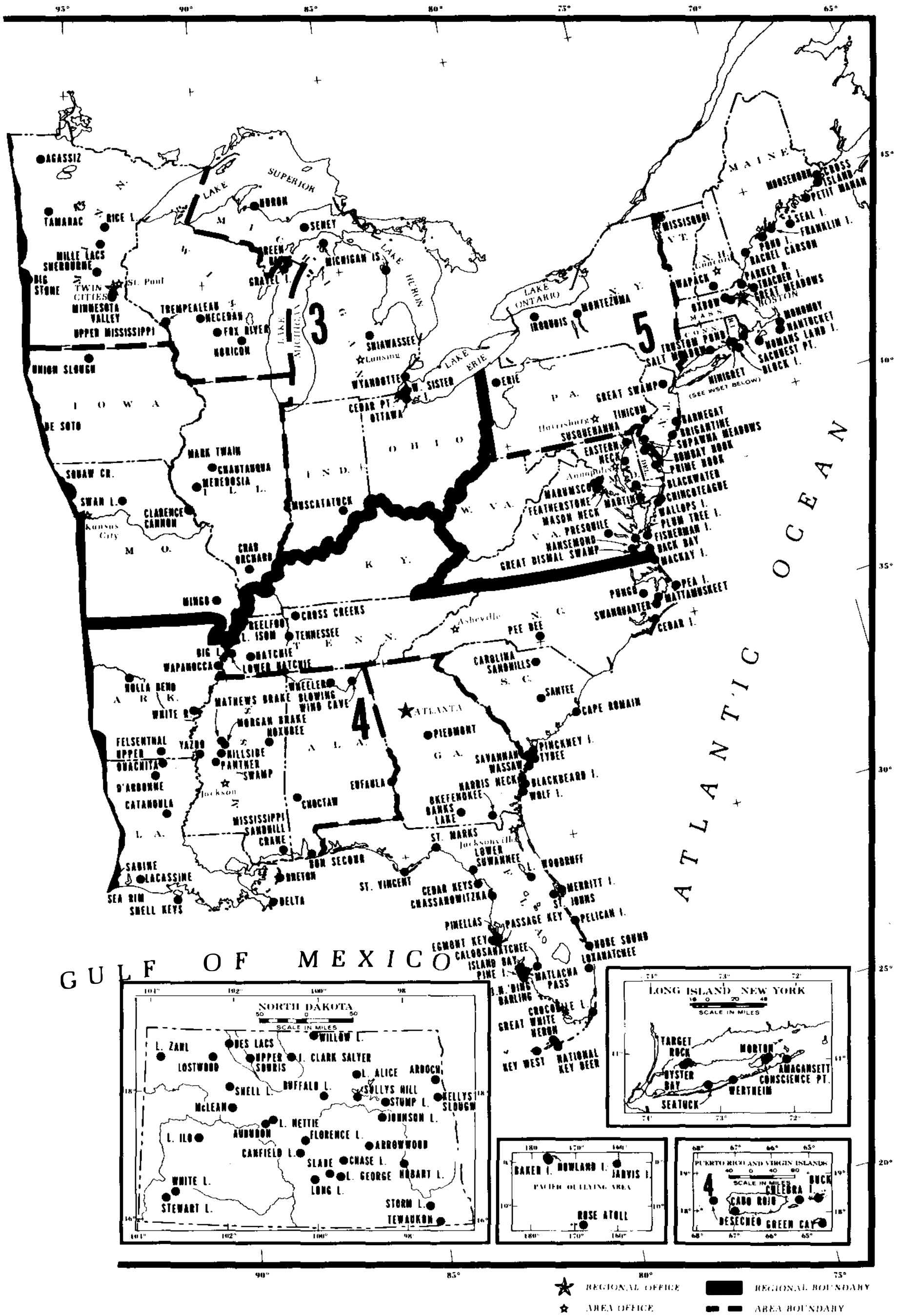


Figure 5. Geographic distribution of lands administered by the U.S. Fish and Wildlife Service.


GULF OF MEXICO
ATLANTIC OCEAN
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
IOWA
ILL.
IND.
OHIO
KY.
TENN.
MO.
ARK.
LA.
ALA.
GA.
S. C.
N. C.
W. VA.
VA.
PA.
N. Y.
VT.
N. H.
MASS.
CONN.
MAINE
3
4
5
AGASSIZ
TAMARAC
RICE L.
MILLE LACS
SHERBURNE
BIG STONE
TWIN CITIES
St. Paul
MINNESOTA VALLEY
UPPER MISSISSIPPI
TREMPEALEAU
NECEDAH
FOX RIVER
HORICON
UNION SLOUGH
DE SOTO
SQUAW CR.
SWAN L.
Kansas City
CLARENCE CANNON
MARK TWAIN
CHAUTAUQUA
MEREDOSIA
CRAB ORCHARD
MINGO
HURON
SENEY
GRAVEL I.
MICHIGAN IS.
SHIAWASSEE
Lansing
WYANDOTTE
W. SISTER
CEDAR PT.
OTTAWA
MUSCATATUCK
ERIE
IROQUOIS
MONTEZUMA
GREAT SWAMP
Harrisburg
TINICUM
SUSQUEHANNA
EASTERN NECK
PRIME HOOK
BOMBAY HOOK
SUPAWNA MEADOWS
BRIGANTINE
BARNEGAT
BLACKWATER
CHINCOTEAGUE
WALLOPS I.
PLUM TREE I.
FISHERMAN I.
BACK BAY
MACKAY I.
NANSEMOND
GREAT DISMAL SWAMP
PRESQUILE
MASON NECK
FEATHERSTONE
MISSISQUOI
MOOSEHORN
CROSS ISLAND
PETIT MANAN
SEAL I.
FRANKLIN I.
POND I.
RACHEL CARSON
PARKER R.
THACHER I.
GREAT MEADOWS
BOSTON
MONOMOY
NANTUCKET
NOMANS LAND I.
SACHUEST PT.
BLOCK I.
NINIGRET
TRUSTOM POND
SALT MEADOW
(SEE INSET BELOW)
PUNGO
SWANQUARTER
MATTAMUSKEET
PEA I.
CEDAR I.
PEE DEE
Asheville
CROSS CREEKS
REELFOOT
L. ISOM
TENNESSEE
HATCHIE
LOWER HATCHIE
BIG L.
WAPANOCCA
HOLLA BEND
WHITE R.
FELSENTHAL
UPPER OUACHITA
D'ARBONNE
CATAHOULA
YAZOO
MATHEWS BRAKE
MORGAN BRAKE
NOXUBEE
HILLSIDE
PANTHER SWAMP
Jackson
WHEELER
BLOWING WIND CAVE
ATLANTA
PIEDMONT
EUFAULA
CHOCTAW
MISSISSIPPI SANDHILL CRANE
CAROLINA SANDHILLS
SANTEE
CAPE ROMAIN
PINCKNEY I.
SAVANNAH
WASSAW
TYBEE
HARRIS NECK
BLACKBEARD I.
WOLF I.
OKEFENOKEE
BANKS LAKE
ST. MARKS
Jacksonville
LOWER SUWANNEE
ST. VINCENT
BON SECOUR
BRETON
DELTA
SABINE
LACASSINE
SEA RIM
SHELL KEYS
CEDAR KEYS
CHASSAHOWITZKA
WOODRUFF
MERRITT I.
ST. JOHNS
PELICAN I.
PINELLAS
PASSAGE KEY
EGMONT KEY
HOBE SOUND
LOXAHATCHEE
CALOOSAHATCHEE
ISLAND BAY
PINE I.
MATLACHA PASS
J. N. 'DING' DARLING
CROCODILE L.
GREAT WHITE HERON
KEY WEST
NATIONAL KEY DEER
NORTH DAKOTA
SCALE IN MILES
L. ZAHL
LOSTWOOD
DES LACS
UPPER SOURIS
J. CLARK SALYER
WILLOW L.
L. ALICE
ARDOCH
SHELL L.
BUFFALO L.
SULLYS HILL
STUMP L.
KELLYS SLOUGH
McLEAN
L. NETTIE
JOHNSON L.
L. ILO
AUDUBON
FLORENCE L.
ARROWWOOD
CANFIELD L.
SLADE
CHASE L.
L. GEORGE
HOBART L.
LONG L.
WHITE L.
STEWART L.
STORM L.
TEWAUKON
LONG ISLAND NEW YORK
TARGET ROCK
MORTON
AMAGANSETT
CONSCIENCE PT.
OYSTER BAY
WERTHEIM
SEATUCK
BAKER I.
HOWLAND I.
JARVIS I.
PACIFIC OUTLYING AREA
ROSE ATOLL
PUERTO RICO AND VIRGIN ISLANDS
BUCK
CULEBRA
CABO ROJO
DESECHEO
GREEN CAY
REGIONAL OFFICE
AREA OFFICE
REGIONAL BOUNDARY
AREA BOUNDARY

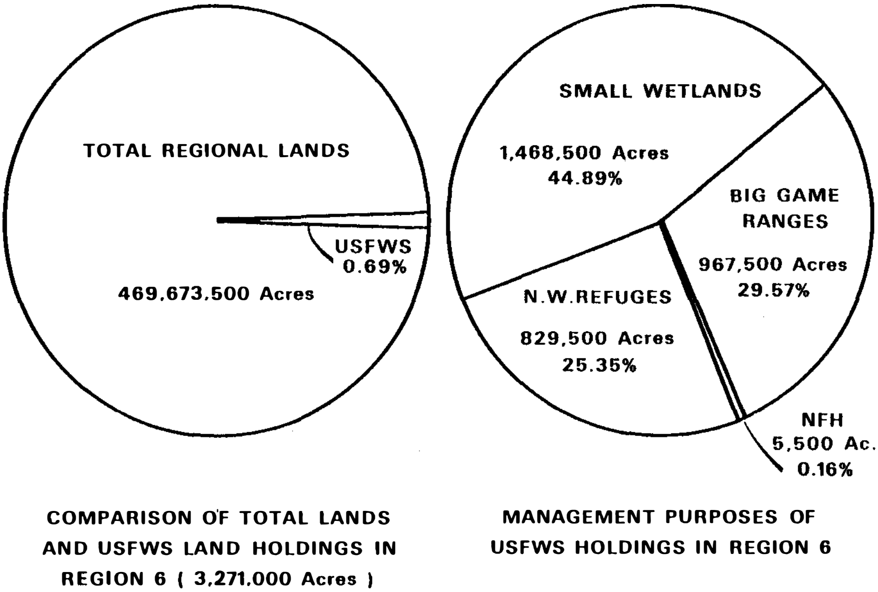


Figure 6. Comparison of total lands and U.S. Fish and Wildlife Service land holdings in Region 6 (3,271,000 acres; 1,324,755 ha).

Federal refuges have also been very important to desert bighorns, bison, and a number of other species.

On the other side of the coin, our land management efforts have not enabled us to maintain some species. We may lose the dusky seaside sparrow despite the creation of St. Johns National Wildlife Refuge. Several refuges are managed to optimize habitat for canvasbacks, but the species is 35 percent below the long-term national population objective. There are currently 181 species of vertebrates which are threatened or endangered in the United States, and a number of other species which are below the desired population levels. This situation exists in the face of our best efforts, including the possession and management of lands.

We have had both successes and failures, but the populations of most species are high enough to satisfy most of the public's needs for wildlife. Undoubtedly, the possession and management of lands by the Fish and Wildlife Service and other federal and state agencies have contributed greatly to this success.

What do we think the future holds? Privately owned lands will be used more and more intensively. An increasing human population will demand more housing, more energy, more transportation corridors, more recreation, more jobs, and, generally, a larger, faster moving economy.

Growing human populations worldwide and increasing standards of living in developing nations are pushing up the world demand for food. But many of these countries cannot meet this demand. United States and Canadian agriculture will meet a substantial portion of this demand and the result will be intense pressure on croplands in North America. No human endeavor has altered wildlife habitat as much as agriculture. Only agriculture has altered hundreds of millions of acres.

This affects not only privately owned croplands, but also nearby public wildlife lands.

In the past, wildlife agencies could acquire scattered tracts of critical wildlife land and manage them with the assurance that surrounding private lands also would contribute food and cover for wildlife. Agricultural practices are changing that. In the Pothole Region, for example, we have many waterfowl production areas which include only a few dozen acres. In some cases, 100 percent of the surrounding land is plowed every fall, leaving zero wildlife habitat on the private side of the property line.

In the West, the public lands will serve as a buffer between wildlife and changes that will occur on private lands. In portions of New England, some changes in land use are actually benefiting some species of wildlife. But in the intensively farmed areas of the South and Midwest, there will be a major shift of wildlife values from the private lands to the small acreages of public lands.

Total wildlife populations probably will decline. This decline may even occur on public lands because of changes on adjacent private lands. But the percentage of the remaining wildlife found on public lands will increase. Therefore, the limited public lands in our intensively farmed regions will become extremely important, both to wildlife and to the people who enjoy wildlife.

One alternative, obviously, is to enhance wildlife production on private lands. Methods to compensate landowners for producing wildlife should be devised and encouraged. But the focus of this afternoon's session is improving management of existing public lands, so let's look at some strategies for public lands.

Since it is likely that more of the demand for wildlife will be met from public lands and less from private lands, a simple and obvious solution is for the Fish and Wildlife Service to buy more land; but this strategy runs head-on into a couple of major barriers. In the Great Plains States, the Federal Government has experienced intense opposition to acquisition of land for wildlife. Most of the state legislatures in my Region have proposed legislation to stop or reduce federal land purchases and, in North Dakota, the proposal has already become law. The anti-acquisition sentiment is drawing strength from the "Sagebrush Rebellion" movement.

All this is occurring against a background of increasing citizen opposition to federal spending. There are some cases where state and local governments and the general public support acquisition of land for wildlife purposes. But it is unlikely that adequate public funds will be available to acquire the needed acreage.

Despite these barriers, Fish and Wildlife Service policy is to continue to buy interests in lands, but certainly not at the same pace as in the past. The rate of land acquisition will decrease sharply. For the most part, we will have to make do with the public lands we now have.

We know that if we manage a parcel of land for one species, we likely will diminish its value for another species. This brings us to a stark reality. We won't be able to maintain the desired population levels for all species.

I believe that the strategy that will enable us to get the most out of our existing Federal lands is to make certain that we do, in fact, have a specific strategy. We must ensure that land management decisions are made in light of the expected contribution to the achievement of State, regional and national wildlife objectives. This kind of planning will force some hard decisions. For example, some agonizing decisions must be made and agreement reached about which species are most important. We can't save them all. As we are forced to make tradeoffs between species, we must know the wishes of those who pay the bill—the American people—and focus on the high priority species. Those species for which we can acquire the technology to achieve the desired results should be targeted. Wildlife professionals should not advocate spending money on low priority species, especially if there is little probability of success.

There are some legal limitations to this proposal. The Endangered Species Act dictates a minimum priority for endangered species and requires that attention be given to those species. Within this legal limitation, however, there is considerable flexibility as to where efforts may be directed. Also, we must be more tough-minded in the identification and analysis of problems. There must be confidence that the problems we decide to attack are truly those which prevent attaining desired wildlife populations.

The same critical thought process should be applied to the selection of strategies to solve those problems. Critical analysis should produce a strong expectation that the strategies selected will really bring the desired result.

Next, we must continue to apply stringent evaluation to discriminate between those activities which are getting the job done and those which are not. The last thing wildlife agencies can afford to do is carry on activities simply because they were done in the past. The prime criterion for evaluating management practices is whether or not they contribute efficiently to wildlife population objectives.

So my first strategy, simply stated, is discipline. Disciplined management means having the courage to clearly establish and commit ourselves to predetermined results, and then insist that land management practices be evaluated only in terms of achievement of those predetermined results at a reasonable cost. The Fish and Wildlife Service has begun a planned approach to the conduct of its business intended to help achieve disciplined management. We solicit your involvement in this endeavor.

A second strategy is the involvement of interested publics in our decision-making process. Public involvement has received considerable attention. This process has produced good results. Repeatedly, programs with public input received in the early stages of development have been successful. On the other hand, when the public is surprised by a final proposal, good programs can be killed or rendered ineffective because of public opposition. This can occur, not because the public necessarily opposed the action, but because it is perceived that a decision was made arbitrarily, without consideration of the public view. The public's viewpoint frequently enables the decision maker—in this case the Fish and Wildlife Service—to evaluate other alternatives in arriving at an end result favorable to the public and government.

Even with public involvement, not everyone is going to agree with the final list, but the end result will be *our* list, not just *my* list. Even though some group might not be totally pleased, they would be far less likely to cast a veto if they knew the list were developed through an objective and reasonable process.

The U.S. Fish and Wildlife Service is increasing the opportunities for public involvement in its decision-making processes. Public involvement is fully integrated into our refuge master planning process.

America is taking a close look at its government—asking, "What is the proper role of the Federal Government?" and "What is the proper role of State governments?" This is a normal and positive evolution in our society. But as I contemplate how this may affect wildlife agencies, I see the potential for increased confrontation, even among professional wildlife managers. It is important to remember that, although we work for different levels of government, we are *one* profession. We have *one* common interest—conservation and wise use of wildlife.

I have had the pleasure of working for both State and Federal wildlife agencies and I want to assure you that if the States and Feds are at odds, we play right into the hands of those who would divide and conquer. We *must* be willing to compromise to achieve unity.

I, for one, stand ready to compromise with other wildlife agencies and other special interest publics. But I am willing to compromise only if others will join with me to develop the best tradeoffs we can possibly develop. Call this public involvement; call it good coordination; call it compromise. Only by working together will we be able to meet most wildlife objectives while enabling others to meet most of their nonwildlife objectives. The one thing we must *not* do is protect turf at the expense of protecting wildlife.

Enhancing Wildlife Values in Urban Areas

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Visual Response to Urban Wildlife Habitat

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Introduction

In designing landscapes which provide habitat for wildlife in our urban areas, the visual preference of residents is a critical factor to be considered. People's preferences for landscapes have been theoretically related to the fulfillment of fundamental needs. The importance of the visual character of habitat is not something to be suppressed or ignored by landscape designers or habitat managers. Where habitat quality and people preference meet is a critical dimension for designers.

S. Kaplan (1973) has developed an informational approach to understanding why certain landscape characteristics influence preference. In this approach, people are viewed as information-processing organisms who rely on visual perception of their environment to provide information necessary for survival. The quantity of information available and the organization of information are two key aspects of the landscape to which people respond. As S. Kaplan (1973) has argued, the evolutionary environment has shaped man's genetic structure, and his needs. Landscape preference, therefore, may be viewed as an expression of fundamental human needs.

From this informational approach to understanding visual preference, Kaplan and Wendt (1972) and S. Kaplan (1975) have proposed six variables which have some role in the prediction of preference. These six variables have been grouped into two categories in terms of the information they provide.

The first category, "promised information," concerns the amount of information likely to become available as one advances into the scene. It meets the need for an environment to offer ". . . novelty, challenge, and uncertainty" (S. Kaplan 1973).

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The two predictors of preference within this category are complexity and mystery. Complexity promises further information upon a greater expenditure of time in inspecting a scene, whereas mystery promises further information upon a change in vantage point by advancing farther into the scene.

The second category of predictor variables, "legibility," concerns the organization of information in a scene. It meets the need for an environment that one can make sense out of, and deals with the spatial arrangement of a scene. Four predictors of preference within this category are: coherence (order, as expressed by patterns, redundant elements, etc.); space (spaciousness); texture (fineness of texture of the ground surface); and edge (presence of distinct boundaries between areas).

A third category of predictors of preference, "primary landscape qualities," has been proposed (S. Kaplan 1975, Gallagher 1977). This category is not based on the amount or organization of information as the first two categories, but deals with the physical components of the landscape which have been found to predict preference, such as trees, wildlife, and water.

It is the goal of this research to determine opportunities and alternatives for incorporating wildlife habitat with high visual preference in the urban environment. The two major objectives are to determine residents' visual preference for wildlife habitat in a residential setting, and to determine the relationship of particular habitat characteristics to visual preference.

Methods

Four neighborhoods within the planned, new city of Columbia, Maryland, were the sites selected for study due to the extensive, varied, residential open space system running throughout Columbia, and the already existing data describing bird species diversity in the open space.

Visual Preference

To determine residents' preferences for wildlife habitat in Columbia, and their attitudes toward open space and urban wildlife, a questionnaire was developed. This questionnaire contained both written questions and black and white photos of Columbia open space to be rated for preference. Black and white photos were used as the most economical and theoretically acceptable simulation technique of the real world (R. Kaplan 1972, 1973, Kaplan et al. 1974, Howard et al. 1972). One hundred twelve photos (35 mm, 45 mm lens) were taken of four different types of open space which represented four varied forms of wildlife habitat: open mowed grass, herbaceous tall grass, woods, and combination areas (made up of two or three of the previous types). Eight photos from each cateogory, for a total of 32, were selected by a jury of four persons familiar with visual resource assessment. The photos were selected based on photographic quality and representation of the category of open space.

The 32 photos were then rated by the same jury as to the presence of seven landscape characteristics which have been proposed as predictors of preference: complexity, mystery, coherence, space, texture, edge and trees. The jury rating was based on a methodology developed by R. Kaplan (1972) and tested by Gallagher (1977). The scale used in the rating was 1 = low content to . . . 5 = high content. Before photographs used in the study were rated, several test photos were discussed until agreement was reached on the rating of a characteristic. This was done to familiarize the jury with definitions.

The 32 photos were randomized, transferred to metal plates, and printed by offset using black ink. Reproduction quality was considered excellent. Respondents to the questionnaire were requested to "Please indicate how much you would like to have the open space portrayed in each photograph as the open space next to your property. Please use the scale where 1 = not at all to . . . 5 = a great deal."

Following the photos in the questionnaire there were eleven questions designed to determine people's attitudes to urban wildlife and open space. Questions dealing with the personal background of the respondents were not included, as Zube (1973) has found no difference in visual preference between sexes, and has found substantial similarity across age groups. The population was also fairly homogenous, being middle- to upper-middle class and predominantly white.

A random sample was taken of residents whose homes bordered open space in the neighborhoods from which photographs of wildlife habitat were selected in this study. This population was sampled because of their familiarity with the landscapes they were rating for preference. Questionnaires were distributed by walking to homes and asking one of the adults of the household to complete it within 2–3 days. The questionnaires were then picked up. People who were not at home were left a questionnaire and a self-addressed stamped envelope. Eighty-one percent (155 of 191) of the questionnaires were either picked up or returned by mail.

Wildlife Habitat Variables

Wildlife habitat characteristics were examined for the same 32 photos of open space which were rated for preference. Since people were rating preference based only on what was visible in the photos, wildlife habitat characteristics were also judged on what was visible in the photos. Two wildlife habitat variables were examined: habitat diversity and vegetation structure. Bird species diversity was also analyzed.

Three wildlife biologists and the jury rated the photos on wildlife habitat diversity. All used the same definition of wildlife habitat diversity, and the same rating scale.

The vegetation structure in each photo was examined for the first 100 feet (30.5m) of each scene. The most critical area for human preference is assumed to be that which is most proximate to the viewer. Also, the vegetation rating was based on photographs and not the usual site specific vegetation analysis; therefore, the problem of photo depth had to be resolved. Alterations to Thomas et al.'s (1977) "arbitrary" five-foot (1.5m) layers of deciduous and coniferous vegetation included separation of mowed grass and herbaceous vegetation into two layers, and combination of several upper height categories. Height classes used in this study were 0–6 inches (0–15.2cm) (mowed grass), 6–24 inches (15.2–61.0cm) (herbaceous vegetation), and four classes of woody vegetation (0–5 feet, 5–10 feet, 10–25 feet and above 25 feet) [0–1.5m, 1.5–3.0m, 3.0–7.6m, and above 7.6m]. In the course of the study it was realized that the last two categories, 10–25 feet and above 25 feet, could not be used because of photographic limitations. The predictor variable 'trees' was used in their place to present a continuity and flow of vegetation for correlation analysis. Each photo was given a rating for each vegetation layer based on the estimated percent coverage of vegetation in that layer. The vegetation density rating scale was based on Kuchler (1967):

Kuchler's Rating			Author's Rating
1	dense:	coverage more than 80%	5
2	semi-dense:	coverage from 50-80%	4
3	open:	coverage from 20-50%	3
4	very open:	coverage from 5-20%	2
5	extremely open:	coverage less than 5%	1

Bird species diversity for the four types of wildlife habitat was also determined. A.D. Geis' wintering bird surveys for 1977 and 1978, and the spring breeding bird surveys for 1976 and 1977, conducted in Columbia, were used in this study (ascertained from personal communication with A.D. Geis). Fourteen bird count blocks along the open space system were used in this study. These blocks were selected because they contained a specific homogenous vegetation character (2–open, mowed grass; 4–herbaceous, tall grass; 5–woods; 3–combination), and photographs of all but one of these areas were used in the questionnaire to be rated for preference.

Results

Predictor Variables

The seven proposed predictors of preference were found to have varying degrees of significance in determining people' preference for open space. A Spearman's Rank correlation of the jury's rating of each predictor variable with the mean preference rating of residents for the 32 photographs was computed (Table 1). The strongest predictors were trees, complexity, and mystery. These were significantly correlated with preference below the .05 significance level.

Strong interrelationships were shown between some of the predictor variables. Trees, complexity, and mystery intercorrelated strongly (x=0.001). Some of the 'legibility' variables correlated positively and significantly: coherence with texture and edge, and space with texture. There was a significant negative correlation of complexity with space and texture, and trees with space and texture. Spaciousness and a fine texture do not create a sense of complexity, nor do they permit an abundance of trees in a scene.

Photo Groups

Photos in the open mowed grass group were dominated by a wide expanse of mowed grass. As expected, the jury rated this group high in space and texture. Other predictors were rated low- to mid-range, with mystery rated lowest. The mean preference score of residents for this type of open space was 3.2.

The herbaceous tall grass group, characterized by a predominance of herbaceous, tall grass in the scene, was rated consistently low in coherence, texture, and edge, and low to mid-range for other predictor variables. This category received the lowest mean preference rating (2.2) by residents.

The woods category of open space was rated consistently high for complexity, mystery, and trees. The 'legibility' variables all rated low to mid-range. This was the most highly preferred category among residents, with a mean preference score of 3.9.

The final group, combination, was represented by photographs incorporating a blend of open mowed grass, herbaceous tall grass, and/or woods. These photos were rated from mid- to high-range for the 'promised information' predictors, complexity and mystery, and also for trees. 'Legibility' variables were rated mid-range. No predictor was rated consistently low. The residents' mean preference rating was 3.3.

Wildlife Habitat Variables

A Spearman's Rank correlation was run between the jury and mean biologist ratings of wildlife habitat diversity with preference and predictor variables. The habitat diversity ratings of the jury and the biologists correlated strongly. The jury's rating correlated significantly with residents' preference, whereas the biologists' rating was barely significant at the .05 level ($r = .33$ at .061 significance level). Both jury and biologist habitat diversity ratings correlated strongly with trees, complexity, and mystery, the three predictor variables important to residents' visual preference. The 'legibility' predictors were either not significantly correlated (coherence and edge), or negatively correlated (space and texture), with habitat diversity.

Ratings were given each photograph for the estimated amount of vegetation present in each of six layers. Correlations were run between vegetation and residents' visual preference, predictor variables, and habitat diversity. There were strong positive correlations between preference and the 0–5 feet (0–1.5m) and 5–10 feet (1.5–3.0m) categories of woody vegetation and trees. A strong negative correlation existed between residents' preference and the 6–24 inch (15.2–61.0cm)

Table 1. Spearman's Rank correlation of predictor variables with residents' preference rating for 32 photographs (n = 151).

Predictor of preference	Spearman's correlation coefficient	Level of significance (x)
Trees	.82	.001
Complexity	.52	.002
Mystery	.44	.012
Coherence	.26	.155
Edge	.14	.45
Texture	.04	.83
Space	–.06	.75

category of herbaceous tall grass vegetation. Predictor variables important to residents' preference (trees, complexity, mystery) correlated significantly with vegetation layers preferred by residents (0–5 feet and 5–10 feet). These two vegetation layers also correlated positively and significantly with wildlife habitat diversity ratings. The mowed grass vegetation layer correlated strongly with all of the 'legibility' variables.

Significant negative correlations were found between space and the two layers of woody vegetation and trees. Habitat diversity ratings of wildlife biologists correlated negatively with the mowed grass vegetation layers.

Bird counts were tabulated for the fourteen homogenous blocks of open space in order to determine the differences in bird species diversity for the four types of wildlife habitat. The woods mean for bird species diversity (13.2 species) was highest. Herbaceous tall grass (10.19) and combination areas (11.42) were also used heavily by birds. As expected, open mowed grass (4.63) contained a significantly less diverse population of birds than the other habitat types.

Written Questionnaire

The written portion of the questionnaire contained eleven questions designed to determine the attitudes to urban wildlife and open space of residents living next to open space. A substantial majority (over 90 percent) of those surveyed felt that open space made Columbia a better place to live. Some comments used by residents in the questionnaire to describe open space included "aura of tranquility," "serene and relaxing," "contribute to some feeling of harmony to our lives," and "one of Columbia's calling cards."

The presence of wildlife was shown by the results of this study to be important to people, and add enjoyment to their lives. Most people (94.7 percent) viewed wildlife near their homes, and a majority (65.5 percent) encouraged it to their yards, by birdfeeders, plantings, etc. Many of the respondents (61.5 percent) said they would like to see more wildlife, and about the same percentage used the open space to view wildlife. A substantial majority (70.9 percent) indicated they received much enjoyment by viewing wildlife. Cauley (1974) found similar results in his study of people's attitudes toward wildlife in a suburb of Detroit.

Over 50 percent of the residents responded positively to five species of wildlife when asked which species they would enjoy seeing near their homes or in their yards. These five species were cardinal, squirrel, cottontail rabbit, goldfinch and box turtle. Starling, garter snake, salamander, fox, groundhog, and opposum all received below 35 percent affirmative vote. These results coincided with those reported by Dagg (1974).

Discussion

When incorporating natural areas into our urban environments as open space for man and as habitat for wildlife, it is important to provide these natural areas in a visually acceptable and preferred manner. Planners, designers, and habitat managers should be aware of basic constraints imposed by human attitudes and desires, which ". . . can be as limiting in land use and development as the most complex of technical considerations" (Foster 1971).

The "promised information" category of predictors of preference (complexity and mystery), along with trees, were found to be the most important elements of a visually preferred landscape. None of the "legibility" predictor variables correlated significantly with preference in this study, although one of the "legibility" predictors, coherence, has been found to be of primary importance in visual preference in other studies (R. Kaplan 1973, Gallagher 1977). Coherence is the element which provides some order to a scene, and aids the viewer in making some sense out of the environment. Gallagher (1977) stated that, " 'Coherence' seems to come first in preference; when 'coherence' is satisfied then interest is shifted to 'complexity'." Complexity, not coherence, was of issue to the people involved in this study; therefore, it is suspected that coherence had been resolved by residents surveyed through their association with the land over a period of time. The importance of complexity and mystery to residents adjacent to the open space supports the finding of Herzog (1976) that increasing familiarity with a landscape decreases preference for simple scenes and increases preference for more complex scenes.

Complexity is closely associated with diversity. According to Gill (1973), "it [diversity] should form the principle focus for management of habitat in urban areas." Considering the significant positive correlation of residents' visual preference with ratings of wildlife habitat diversity, designers of urban environments should have little problem with visual preference in incorporating diversity into urban landscapes.

Vegetation has been termed the key to wildlife habitat (Komarek 1964) because it is essential to wildlife as food, cover, and reproductive sites. The physiognomy of vegetation in layers above the ground has also been shown to have a direct effect upon number and diversity of bird species present (MacArthur et al. 1962, Thomas and DeGraaf 1975). Since vegetation is so critical for wildlife, it is important that the 0–5 foot (0–1.5m) and 5–10 foot (1.5–3.0m) layers of woody vegetation, and trees, correlated positively and significantly with residents' preference for open space. It is suspected that the strong negative correlation of preference with the 6–24 inch (15.2–61.0cm) category of herbaceous tall grass was due, in part, to the weedy, unkempt appearance this vegetation produced in Columbia. With studies such as Thomas et al. (1974) showing specific bird species' preference for distinct layers of vegetation, and knowing people's preferences for vegetation and wildlife, the designers of urban environments may more easily provide urban wildlife in the future.

The four categories of open space examined in this study, open mowed grass, herbaceous tall grass, woods, and combination, were found to offer different potentials for incorporating wildlife habitat into the visually preferred environment. The open mowed grass category of open space may not be as visually preferred as expected. Though this category received a mean residents' preference score of 3.2 (similar to the combination category score of 3.3), it is suspected that a lower mean preference score would have been found if two of the photos (rated substantially higher) had not had a distant background of trees. Too large of an expanse of nothing but mowed grass will be too simplistic and lack the complexity, mystery, and trees important to a visually preferred landscape. Only the predictors space and texture were rated high in the mowed grass category, which designers of open space may consider in increasing legibility and coherence for people who have had little experience with natural landscapes.

The herbaceous tall grass category of open space was rated significantly lower than all other categories for preference by residents surveyed. This may be due to the particular situation in Columbia, where homogenous stands of Kentucky-31 Fescue, a sterile, tall grass, have been planted, and were present in many of the photos of this category. Also many residents in Columbia resented the change in open space mowing policy that created this situation. No predictors of preference were rated high by the jury, with coherence, texture and edge being rated consistently low. One positive factor about incorporating this type of open space into the urban environment is its benefits to wildlife diversity, as evidenced by the high bird species diversity contained in this category. On its own it may be difficult to have the herbaceous tall grass category accepted visually in the urban environment; however, it can be incorporated into the combination category, which is more desirable, or used in non-visible areas away from residents' homes. Also, if this category had been defined to include more broad-leaved vegetation, and more plant diversity with many more wildflowers, it is expected that this category would have been more visually preferred, and may also have been rated higher by the jury for some of the predictors of preference.

The woods category of open space was the most preferred by residents, was rated high by the jury for predictors of preference important to residents (trees, complexity, and mystery), and had the greatest, most stable diversity of bird species. Though it was rated low- to mid-range by the jury for "legibility" predictors of preference, the woods category can be incorporated into the combination category to supply more coherence for those less experienced with natural environments.

The combination category may be the most readily accepted type of open space for the greatest amount of people. It was rated second in preference by residents surveyed, rated mid- to high-range for "promised information" predictors of preference and trees by the jury, and also rated mid-range for 'legibility' predictors. Designers of urban landscapes could fulfill the needs of those desiring a more challenging landscape, and at the same time provide legibility to those less experienced with the natural environment. Wildlife diversity would also be expected to be high owing to the diversity of vegetation present.

Conclusion and Recommendations

This study indicates that good wildlife habitat can be incorporated into residential open space systems in a visually preferred manner. Residents have indicated their preference for the appearance of diverse wildlife habitats, and have expressed their desire to see wildlife. Since mowed grass areas have a less preferred appearance and low value as wildlife habitats, a good management strategy would be to allow portions of mowed grass areas to revert to natural vegetation through natural succession. An increased diversity of vegetation and wildlife would result, consequently enhancing visual preference. Open space maintenance costs would be reduced, and other environmental benefits would be provided.

The provision of visually preferred wildlife habitats into our urban environments can best be accomplished through the support of urban planners and managers, and by landscape architects and wildlife biologists integrating their concepts of good landscape design.

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Perceptions of Residential Wildlife Programs

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Introduction

Urban habitat is thought by some to be a "last refuge" for certain wildlife species in the face of diminishing natural habitat. Urban wildlife can also benefit urbanites by putting them back in touch with nature (Allen 1974). One type of urban habitat with potential for wildlife aggregations is residential or "backyard" habitat. It is important to know how man will react to the development of habitat at his residence and to any wildlife attracted, when considering utilization of residential habitat for wildlife.

Several studies have examined human behavior, attitudes and responses toward urban wildlife. Dagg (1970) examined the reactions of residents of Waterloo, Ontario towards urban wildlife. Cauley (1974) surveyed a Detroit suburban area. Shaar (1979) examined attitudes of residents in the Quebec City region towards urban wildlife. Brown et al. (1979) examined wildlife interests and attitudes of metropolitan New York residents. These studies involved sampling the general public in a particular area about urban wildlife.

Our definition of urban wildlife was restricted to residential wildlife, and we restricted the general public to individuals involved in programs to encourage residential wildlife by making food, water, and/or cover available at their residence. The purpose of our study was to examine how individuals actively involved in programs to encourage wildlife were perceiving activities involved with these programs and any wildlife attracted. The information provided by these individuals would best inform wildlife biologists how to help individuals encourage residential wildlife and how more people could be encouraged to become involved in these activities.

Methods

A nationwide survey was conducted to evaluate respondents' perceptions of residential wildlife. A list of participants in the National Wildlife Federation's backyard wildlife program was obtained through the National Wildlife Federation. A six-page questionnaire was developed and sent to the 1,347 individuals on the list in October of 1979. The questionnaire consisted primarily of structured questions, but space was available for additional comments. An introductory letter and postage-paid return envelope were included with the questionnaire. Results of this survey were evaluated using the Statistical Analysis System (Barr et al. 1979).

Study Populations

In May of 1973 the National Wildlife Federation initiated its backyard wildlife program. Certification in this program required that the applicant's backyard provide wildlife with basic habitat essentials, and that a detailed application be submitted. The number of certified backyard habitats in July of 1980 was 1,833 (C.

Tufts, pers. comm.). Individuals in the program at this time came from 48 states, Puerto Rico, and Canada.

The application for certification in the backyard wildlife program requested information on the kinds and numbers of vegetation in the applicant's backyard, wildlife species observed, and methods used to attract wildlife. Due to the effort involved in becoming certified, we assumed that anyone who received certification was interested in and actively encouraging residential wildlife. For this reason, the 1,347 applicants who had received certification by the fall of 1979 were chosen as a study population.

Results and Discussion

Response

Questionnaires were mailed to 1,347 participants in the National Wildlife Federation's backyard wildlife program. Eight hundred and sixty-two questionnaires were completed and returned for a usable response rate of 64 percent. The typical survey respondent was highly educated (66 percent had completed some college or professional school), older (24 percent were retired), lived in a self-owned home (98 percent), and was highly motivated regarding residential wildlife (57 percent spent over $100). The average size of the respondents' backyards was 3.5 acres (1.44 ha), with a range of 0.02 to 125 acres (0.008 to 50.59 ha). Three characteristics of respondents were compared to those of the general public as found in the 1970 census results (U.S. Bureau of the Census 1972) (Table 1).

Benefits

Respondents were asked to identify benefits they received from attracting wildlife to their residence. Respondents indicated that enjoyment (99 percent), beauty of wildlife attracted (92 percent) and helping wildlife survive the winter (91 percent) were the main benefits. Eighty-six percent of the respondents cited the educational value for children of a setting made more natural by the presence of wildlife. Encouraging others to become involved in residential wildlife programs might also be considered a benefit of wildlife attraction which 74 percent of the respondents engaged in. It appeared that respondents encouraged wildlife because they obtained pleasure from doing so, plus they felt they were helping wildlife. Educational values and involving others enabled respondents to share benefits and concerns for wildlife with others.

Table 1. Three major characteristics of survey respondents compared to 1970 census results.

Characteristic	Survey respondents percentage	Census results percentage
Self-owned home	98	59
Retired	24	16
College or professional education	66	22

Perceived Wildlife Response

We examined respondents' perceptions of how wildlife was responding to residential attraction attempts. Respondents were asked which type of wildlife they encouraged at their residences. Not surprisingly, the two most popular groups were birds (100 percent) and mammals (80 percent). Amphibians were encouraged by 63 percent of the respondents and reptiles by 49 percent.

Respondents were asked to indicate changes in the variety of wildlife groups observed since they began encouraging wildlife at their residence (Table 2). Similar results were seen when respondents were asked to indicate their perceptions of changes in total numbers of wildlife observed. The results confirmed that an accurate estimate of changes in both variety and total numbers of wildlife required the ability to recognize species and record observations systematically. Large percentages of respondents indicated that there was no change or they were uncertain of any change in amphibians and reptiles. These results were a measure of respondents' perceptions of population changes and probably do not reflect real population shifts.

Perceived Success

Respondents were asked to rate how successful they were at attracting wildlife. Forty-five percent stated they were highly successful at attracting wildlife, 54 percent stated they were fairly successful, and only 1 percent stated they were unsuccessful. These results are not surprising in view of the inherent biases. Chi square analysis was conducted to determine what factors, if any, were affecting respondent's perceptions of their success. The more successful an individual perceived him or herself to be at wildlife attraction, the more likely the individual was to:

1. encourage mammals ($p = 0.0184$), reptiles ($p = 0.0030$), and amphibians ($p = 0.0003$),
2. use more bird houses ($p = 0.0002$),
3. spend more money attracting wildlife ($p = 0.0001$),
4. encourage the involvement of others in residential wildlife attraction ($p = 0.0001$),
5. consider education ($p = 0.0001$), increasing property value ($p = 0.0028$) and helping wildlife survive the winter ($p = 0.0001$) to be benefits of wildlife attraction.

Table 2. Perceived changes in variety of wildlife groups observed.

Wildlife group	Increase % (no.)	Decrease % (no.)	No change/uncertain % (no.)
Winter birds	80 (680)	5 (40)	15 (130)
Summer birds	70 (593)	4 (39)	26 (217)
Mammals	44 (373)	11 (92)	45 (385)
Amphibians	26 (221)	8 (71)	66 (558)
Reptiles	18 (153)	12 (98)	70 (599)

Problems

We examined the types of problems associated with residential wildlife attraction. The problem cited most often by respondents was dogs and cats scaring wildlife (61 percent). Thirty-eight percent of the respondents said that attracting undesirable wildlife species was a problem and 28 percent said adjacent land use disturbance was creating a problem. Respondents were then asked what problems they attributed to residential wildlife. Twenty-four percent of the respondents indicated that residential wildlife attracted dogs and cats, 22 percent said that wildlife damaged gardens, lawns or shrubbery, and 20 percent said wildlife was "dirty," referring to droppings and seed hulls. Wildlife species blamed most often for these problems were starlings (*Sturnus vulgaris*, 30 percent), house sparrows (*Passer domesticus*, 22 percent), moles (Talpidae, 23 percent), and squirrels (Sciuridae, 22 percent). Most respondents did not appear to take these problems too seriously since they did not stop encouraging wildlife. It appeared that the benefits of residential wildlife outweighed any difficulties experienced.

We examined perceptions of pet predation on residential wildlife which seemed to concern many respondents. Cat predation was of primary interest, but dogs and wildlife predators were also considered. Seventy-seven percent of the respondents had observed cats frightening wildlife at their residence, but only 26 percent said that cats were keeping wildlife away. Cats were directly observed preying on wildlife by 48 percent of the respondents and indirectly observed by 57 percent. Cats were most frequently observed preying upon birds (90 percent) and mammals (44 percent). Seventy-three percent of the respondents had attempted to solve cat problems. Attempts were rated highly successful by 18 percent of the respondents, fairly successful by 54 percent, and unsuccessful by 28 percent. Animals other than cats were directly observed preying on wildlife by 28 percent of the respondents. Indirect observations were made by 16 percent of the respondents. Nonfeline predators observed most often were hawks (Accipitridae, 25 percent), dogs (Canidae, 16 percent), owls (Strigiformes, 8 percent), and snakes (Serpentes, 6 percent). Predation by cats was observed more frequently than predation by either dogs or wildlife predators. It appeared that cats were the most obvious and may be the only serious predators on residential wildlife in urban areas. More research is needed on the role of cats as predators on residential wildlife.

Several problems experienced by individuals encouraging residential wildlife were caused by people. Complaints from neighbors or city officials who would prefer a well-manicured yard to backyard wildlife habitat can create many problems. Respondents were asked if complaints from city officials or neighbors were a problem. Twelve percent of the respondents had received complaints from neighbors, while 3 percent had received complaints from city officials. These complaints do not appear to be widespread, but they can be serious when city mowing and weed control ordinances are involved. It appeared that in most cases if neighbors or officials knew the reason behind the "unkempt" yard, there were not as many complaints. Other people-originated problems experienced by respondents were adjacent land use disturbance (28 percent), children frightening wildlife (4 percent) and vandalism to feeders, birdhouses, or nest boxes (5 percent).

Desired Assistance

Many respondents commented on the kinds of assistance that would be helpful to them in attracting wildlife. Respondents stated that they needed assistance in: solving conflicts between cats and wildlife (29 percent), controlling wildlife pests (1 percent), meeting expenses of wildlife attraction (1 percent), and acquiring information on attracting particular wildlife species (1 percent).

Lack of information did not appear to be a serious problem for respondents since only 5 percent said that a lack of information made wildlife attraction difficult. However, providing information on specific wildlife topics to interested persons would probably help them be more successful at attracting wildlife and gain more satisfaction from these activities.

Conclusions and Recommendations

Respondents attracted wildlife to their residences because they found the presence of wildlife personally beneficial and because they derived feelings of satisfaction from helping wildlife. Birds and mammals were the preferred wildlife groups in residential areas. The major problems respondents faced in attracting wildlife to their homes were dogs and cats scaring wildlife, undesirable wildlife species keeping more desirable species away, and the deleterious effects of adjacent land use disturbance. The problems residential wildlife were most often blamed for included attracting dogs and cats, damaging lawns and gardens, and sanitation problems. Many respondents were concerned with wildlife becoming an easy target for predators, particularly cats, in residential areas. Needs expressed by individuals involved in encouraging residential wildlife were assistance in solving conflicts between cats and wildlife, avoiding wildlife pests, and meeting the expenses of wildlife, avoiding wildlife pests, and meeting the expenses of wildlife attraction. Information on attracting particular wildlife species was desired by some respondents.

Natural resource managers can assist individuals participating in residential wildlife attraction and encourage others to become involved through education. Results of this study suggest that providing the public with more exposure to basic ecological principles would be helpful. Satisfaction with wildlife attraction activities could be increased by providing individuals with information on wildlife identification and on keeping records of species observed. Specific information on amphibians and reptiles might help individuals become more receptive to them. Pet owners should be made aware of the problems caused by roaming pets. Enactment and enforcement of leash laws for both dogs and cats is needed. Participants in backyard wildlife programs need help in giving preferred wildlife an advantage over cats and other vertebrates. Practical information on removal and avoidance of undesirable wildlife species should be made available to wildlife attractors. Participants in backyard wildlife programs would also be helped by providing information on attracting particular wildlife species.

To increase the extent of participation in wildlife attraction programs, study results indicated that information should be made available to the general public, particularly those who have had no college education and are in middle to lower-middle income groups. In order to maintain participant interest, information on cutting the costs of wildlife attraction should be made available. Interest in residential wildlife is likely to develop into interest in wildlife in its natural setting. Interest in residential wildlife, especially if expressed in the voting booth, should prove beneficial to wildlife and natural systems in general.

Acknowledgements

We thank W.D. Warde for assistance with statistical analysis. We also thank Craig Tufts of the National Wildlife Federation for his help with the survey. Funding for this study was provided by the National Wildlife Federation's Conservation Fellowship Program and the Oklahoma Cooperative Wildlife Research Unit.

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Urban Bird Communities and Habitats in New England

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The field of urban wildlife research and management has grown considerably in the last decade. Since 1946 when the need for such work was articulated (Bennitt 1946) at the 11th North American Wildlife Conference, a fair amount of research has been conducted. We can no longer say that such efforts are rare. In addition to research, a body of management information has been developed.

Much of the urban wildlife research to date has concerned birds. Birds are the most obvious group of urban wildlife populations—most species are diurnal and conspicuous by song or sight. Because they are comparatively easy to census in the breeding season, most bird studies have been based on estimates of singing males. Likewise, most urban bird studies have described the habitat associations of various species or the effects of urbanization on individual bird species.

We present here a discussion of both breeding season and winter avifaunas in urban residential and suburban habitats. Bird communities and their habitat associations are presented in terms of functional units or guilds. The knowledge of the responses of birds and other wildlife to urbanization is needed if we want to increase their variety and so make residential areas more interesting places in which to live. Detailed information about the habitat features that are important to species and groups are useful management considerations.

Bird communities have been described for several cities in the United States and Canada. Geis (1974) documented annual changes in the birdlife of Columbia, Maryland, as that new town was being built. Weber (1975) described the nesting substrates used by birds in Vancouver, British Columbia; Lancaster and Rees (1979) related Vancouver's bird communities to its habitat structure.

Changes in the Cambridge, Massachusetts, birdlife over the period 1860 to 1964 were described by Walcott (1974): many former nesting species occurred only as summer transients, and ratios of insectivorous migratory summer residents to seed eaters and omnivorous permanent residents decreased. Emlen (1974) compared the avifaunas of Tucson, Arizona, and the surrounding desert, and reported a great increase in the number of seed eaters as the city spread.

During June and January, 1975–1980, birds and their habitat associations were studied in suburban Amherst and urban Springfield, Massachusetts. The purpose of the study was to describe the breeding season and winter bird communities and relate them to habitat features.

Study Areas

Three study tracts were located in Amherst, a university town in western Massachusetts (pop. 15,000). Tracts were in homogeneous residential areas ranging from 10 to 40 years in age. These tracts were characterized by single-family homes on large, well-landscaped lots 1.25–2.5 acres (0.5–1 ha) in size.

Two study tracts were located in urban residential areas of Springfield (pop. 200,000). Both tracts were in a homogeneous neighborhood approximately 50 years old. Lot sizes were small—0.25–0.5 acre (0.1–0.25 ha)—and the streets were lined with large shade trees.

Methods

Urban bird censuses were conducted in June 1975–76 and in January 1976–77, and suburban censuses were conducted in June 1975–79 and in January 1976–80. Ten breeding season censuses of singing males were made between 5:30–8:30 a.m. EDT on clear, calm days. Five winter censuses were made 8:00–11:00 a.m. EST on clear, calm days when the temperature was above 10°F (–12°C).

Sixty suburban study plots and 40 urban plots were established along streets in contiguous groups of 20. Birds were censused from streets by counting singing males in the breeding season, and all birds in winter, while walking a 110-yard (100m) transect through each plot in 3 minutes. Boundaries were marked on large scale (1:3750) aerial photographs which were carried in the field to help determine whether birds were on or off plots.

Field measurements of habitat features were diameter breast height (DBH), total height, and height to crown of deciduous and coniferous trees, numbers and height of deciduous and coniferous shrubs, the areas of lawn and herbaceous weedy growth, numbers of dwellings and the distance to the nearest woodlot 1.25 acres (0.5 ha) in area. From these field measurements a total of 19 habitat features were derived; calculated features included the deciduous and coniferous tree densities and richness, and ratios of coniferous to deciduous trees and shrubs.

Tree heights were measured with an altimeter, height to tree crown, and shrub heights were measured with a range pole. Numbers of dwellings and woodlot distances were taken from aerial photographs.

Correlations with habitat features are presented for breeding and wintering bird species, but more importantly, for guilds of these communities as well. Guilds are functional groups of species of similar habitat use patterns (Holmes et al. 1979, Root 1967, Salt 1953). For this analysis, we used a classification, similar to that of Willson (1974), as follows:

FORAGING:

Primary Food Habit	*Substrate*	*Foraging Behavior*
(1) seed eater	(1) bark	(1) bark excavator
(2) frugivore	(2) ground	(2) gleaner
(3) insectivore	(3) lower foliage/branch	(3) forager
(4) omnivore	(4) upper foliage/branch	(4) sallyer
(5) carnivore	(5) air	(5) screener
	(6) water	(6) hover-gleaner
		(7) wader
		(8) hawker

Hence, a three-digit code is used to describe a species' major food, foraging substrate and feeding behavior. For example, the mourning dove would be coded

123.[1] Nesting guilds were as follows: (1) ground/herb, (2) in shrubs, (3) on tree twigs, (4) on tree branches, (5) in tree cavities or crevices, (6) in or on buildings, and (7) nest parasite.

Results and Discussion

Results will be presented in two parts—a two-year comparison of urban and suburban avifaunas and habitats and then an examination of the five-year study of the suburban avifauna's habitat associations.

Urban and Suburban Avifaunas

In the two-year study of urban and suburban avifaunas, a total of 60 species were recorded. Urban bird densities were more than 2.5 times greater in the breeding season than suburban densities. In winter, total urban bird density was 1.7 times greater than that in the suburban habitat (Table 1).

The suburban bird community contained 50 species in the breeding season while the urban community had 19; in winter, the suburban community contained 28 species, and the urban habitat contained 20.

If we consider these bird communities' guild structures, it is clear that in the breeding season, ground-foraging seed eaters and omnivorous ground foragers are the most abundant groups in both habitats, and that members of these guilds occur in much greater numbers in the urban habitat (Figure 1). These guilds have been found to dominate urban and suburban avifaunas in Florida (Woolfenden and Rohwer 1969) and in Arizona (Emlen 1974). Other foraging guilds are also important in the suburban habitat in the breeding season, most notably the insectivores. Of all 31 additional species in the suburbs, 21 species were insectivores (Table 1). Only two insectivorous guilds were represented in the city habitat in the breeding season and only one such guild in winter. Among insectivores in the suburban

[1]Scientific names shown in Appendix I.

Table 1. Mean breeding and wintering density and guild designations for birds in urban and suburban habitats.[a]

	Foraging guild			Breeding density (Pairs/100 acres)[b]		Winter density (Birds/100 acres)[b]	
Species	Breeding season	Winter	Nesting guild	Urban	Suburban	Urban	Suburban
Ring-necked pheasant		423					0.40
Rock dove	423	423	6	51.70**		78.80**	0.07
Mourning dove	123	123	4	9.00	6.10	1.20	11.00**
Ruby-throated hummingbird	436		4		0.10		
Common flicker	322		5		0.80**		
Pileated wookpecker		311					0.27
Hairy woodpecker	312	312	5		0.60**	0.40	0.67
Downy woodpecker	312	312	5	0.10	0.43	2.40	2.53
Eastern kingbird	354		3		0.27*		
Great crested flycatcher	354		5		0.13		
Eastern phoebe	354		6		1.17**		
Eastern wood pewee	354		4		0.50**		

Table 1. Mean breeding and wintering density and guild designations for birds in urban and suburban habitats.[a] (continued)

Species	Foraging guild: Breeding season	Foraging guild: Winter	Nesting guild	Breeding density (Pairs/100 acres)[b]: Urban	Breeding density (Pairs/100 acres)[b]: Suburban	Winter density (Birds/100 acres)[b]: Urban	Winter density (Birds/100 acres)[b]: Suburban
Tree swallow	355		5		0.07		
Blue jay	423	423	4	26.70**	14.53	18.00	38.53**
Common crow	423	423	4	0.60	0.60	0.40	0.60
Black-capped chickadee	332	433	5	1.00	3.37**	4.00	29.47**
Tufted titmouse	332	433	5	0.40	0.93	1.40	3.13
White-breasted nuthatch	312	312	5		1.40**	1.60	8.13**
Red-breasted nuthatch	312	312	5	0.10	0.10		0.60**
Brown creeper	312	312	5		0.07		0.80
House wren	332		5		5.67**		
Mockingbird	423	233	2	0.30	2.30**	3.00*	1.20
Gray catbird	423		2	0.20	4.60**		
Brown thrasher	423		2		0.07		
American robin	423		4	76.20**	37.53		
Wood thrush	423		4		2.63**		
Hermit thrush	322		1		0.03		
Swainson's thrush	322		3		0.07		
Cedar waxwing	243	243	3		0.13		2.80
Starling	423	423	6	50.90**	30.03	175.00**	39.27
Red-eyed vireo	332		3	0.20	1.40**		
Warbling vireo	342		3		0.03		
Blue-winged warbler	332		1		0.03		
Yellow warbler	332		2		0.43*		
Blackpoll warbler	332		4		0.17*		
Ovenbird	322		1		0.10		
Common yellowthroat	332		1		0.13		
American redstart	332		3	0.20	0.17		
House sparrow	123	123	6	195.90**	10.87	93.80**	23.87
Eastern meadowlark	322		1		0.03		
Red-winged blackbird	423		2		0.73**		
Northern oriole	443		3	2.10	3.47		
Common grackle	423		4	20.00	15.23		
Brown-headed cowbird		123					0.33
Scarlet tanager	342		3		0.77**		
Cardinal	423	123	2	0.90	4.60**	2.40	5.07
Rose-breasted grosbeak	433		3		0.30*		
Evening grosbeak		123				6.80	57.33**
Purple finch		123					3.00**
House finch	423	123	3	1.00	0.57	5.60	2.27
Pine siskin		123					1.60
American goldfinch	423	123	2		0.70**	2.00	24.53**
Rufous-sided towhee	423		1		0.40**		
Northern junco		123				16.00	11.27
Tree sparrow		123				0.60	8.53**
Chipping sparrow	423		2		2.97**		
Field sparrow	423		1		0.03		
White-throated sparrow		123				2.00	8.87**
Swamp sparrow	322		1		0.07		
Song sparrow	423	123	1		5.40**	0.20	1.00*
				437.5	162.83	415.60	287.14

[a]n = 40 urban plots, 60 suburban plots.
[b]Significantly greater values (Student t) between habitat types denoted as follows: $*P < 0.05$, $**P < 0.01$.

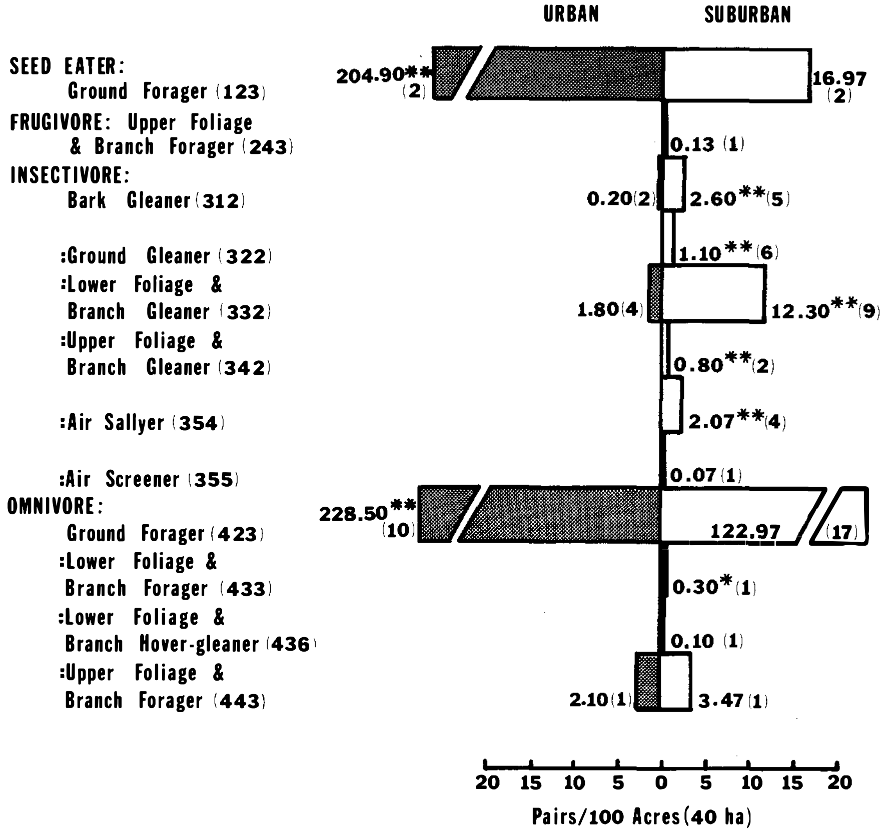

Figure 1. Breeding season foraging guilds in urban and suburban habitats. ( ) = number of species.

habitat, lower foliage gleaners predominated in the breeding season and bark gleaners in winter (Figure 1).

Among the seven nesting guilds we developed for this study, only two—those nesting on tree branches and in or on buildings—were found in significantly greater numbers in the urban habitat. Robins, blue jays and mourning doves, which nest primarily on tree branches, were all more abundant in the urban habitat, as were house sparrows, starlings and rock doves—common nesters on or in buildings. Ground nesters were absent in the city, and members of guilds nesting in shrubs, on tree twigs, or in cavities occurred at significantly lower densities there (Figure 2).

If we combine nesting guild locations and foraging guild substrates, a classification of "habitat associates" can be formed. Thus, for the breeding season, we can compare groups comprised of birds with similar feeding and nesting characteristics. From this comparison, we find that only two "habitat associates"—tree branch nesting ground foragers and building nesting ground foragers—occur at

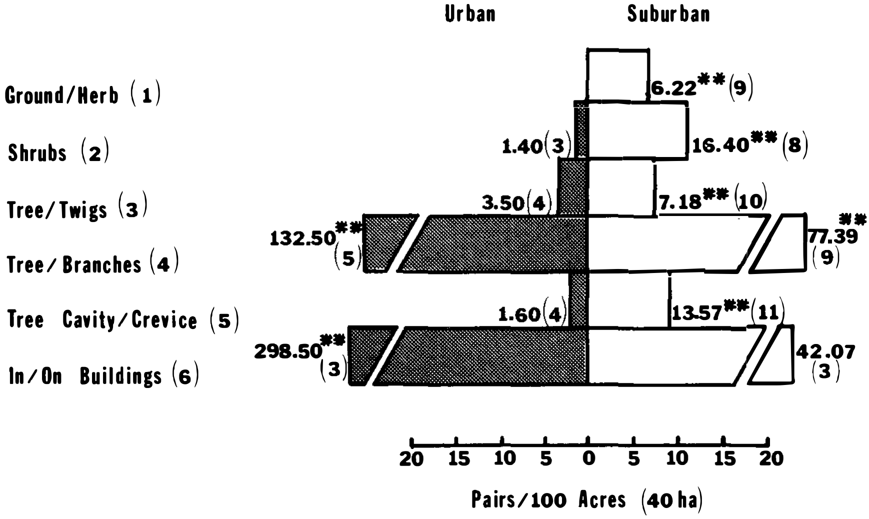

Figure 2. Nesting guilds in urban and suburban habitats. ( ) = number of species.

significantly greater densities in the urban area. The suburban habitat had a greater variety of "habitat associates," notably ground nester/foragers, shrub nester/ground foragers, twig nester/foliage foragers, and cavity nester/foliage foragers (Figure 3).

What differences in habitat structure between city and suburb may account for these bird community differences? Except for the DBH of deciduous trees, other measures of tree cover had significantly higher values in the suburban habitat, most notably the densities of both deciduous trees and conifers. The greater tree

Table 2. Comparison of habitat features in urban and suburban habitats.[a]

Feature	Urban	Suburban
Deciduous tree DBH (in.)	14.34** (36.42 cm)	9.24 (23.47 cm)
No. deciduous trees	18.45	99.10**
Coniferous tree height (ft.)	52.85 (16.11 m)	72.21** (22.01 m)
Coniferous tree height to crown (ft.)	9.78 (2.98 m)	17.52** (5.34 m)
No. coniferous trees	6.23	75.73**
Coniferous shrub height (ft.)	6.99** (2.13 m)	2.92 (0.89 m)
No. coniferous shrubs	74.83	127.25**
Coniferous: deciduous tree ratio	0.39	0.83**
Area of "weedy" growth (ft.^{2})	411.42 (38.22 m^2)	3459.09** (321.36. m^2)
Area of mowed lawn (ft.^{2})	6948.82 (645.57 m^2)	40412.12** (3754.41 m^2)
No. dwellings	8.55**	5.10
Woodlot distance (ft.)	1411.42** (430.20 m)	558.40 (170.20 m)
No. tree species	7.40	19.43**

[a]= Significantly greater values (Student t) between habitat types denoted as follows: *$P < 0.05$, **$P < 0.01$.

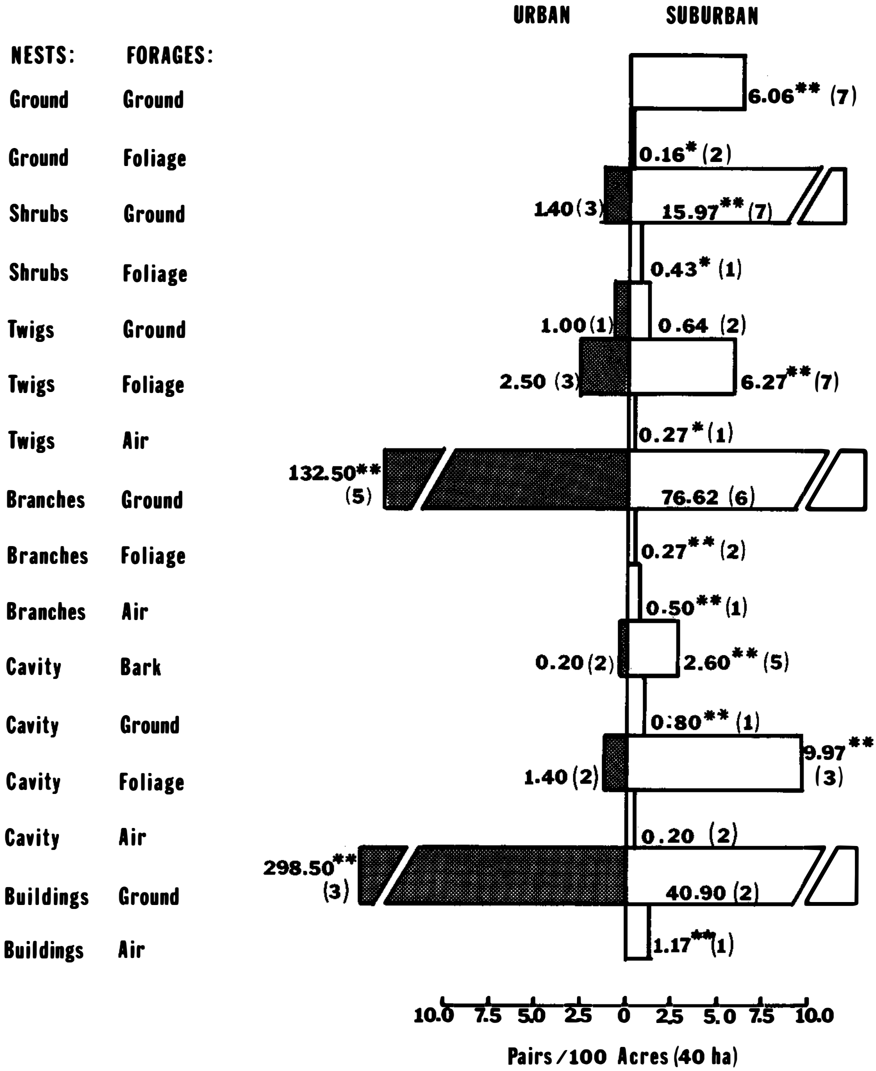

Figure 3. "Habitat associates" of urban and suburban avifaunas. ( ) = number of species.

cover, species richness, shrub density, area of weedy growth, and nearness of woodlots probably contribute to the variety of the suburban avifauna (Table 2).

Correlations between breeding season foraging guild occurrences and habitat components are shown in Table 3. Several patterns of habitat use can be seen. Insectivores are positively associated with the tree features that are characteristic of the suburban habitat, and all except the air screeners, which require a degree of openness, are negatively associated with lawn area. Most insectivorous guilds show an affinity for woodlot nearness. Woodlots are a marked suburban characteristic. Ground foraging seed eaters and omnivores, which so dominate the urban avifauna, show no affinities for woodlots (Table 3).

In winter, bark gleaners and excavators, much more abundant in the suburbs, were strongly associated with the greater tree cover there. Ground foraging seed eaters and omnivores were the most abundant foraging guilds in both habitat types; omnivores, which included the rock dove and starling, reached the highest density of any guild in the city in winter (Figure 4). Both of these species are associated with buildings for winter roosts; the high urban building density and relatively sparse tree cover (Table 2) evidently provided ideal winter habitat for these tolerant species.

Suburban Avifauna and Habitat Associations

Both breeding season and winter bird censuses were conducted in suburban Amherst, Massachusetts, for five years. These three additional census years added 14 species in the breeding season, but most were single sightings (Table 4). Hence, these 14 species had a combined density of only 1.3 pairs/100 acres (40.5 ha), or 0.70 percent of the total breeding bird density. In winter, four species were added in the additional three years; their combined density was 1.83 birds per 100 acres or 0.68 percent of total winter density. Two additional foraging guilds and one nesting guild were encountered during the breeding season and one foraging guild was added in winter (Figures 1, 2, 4, 5 and 6).

The added years of bird census thus enabled us to better describe the total avifauna even though the new species encountered had low densities. The major advantages of the longer-term study were the ability to detect possible trends in bird numbers and the ability to use more representative mean bird values in habitat

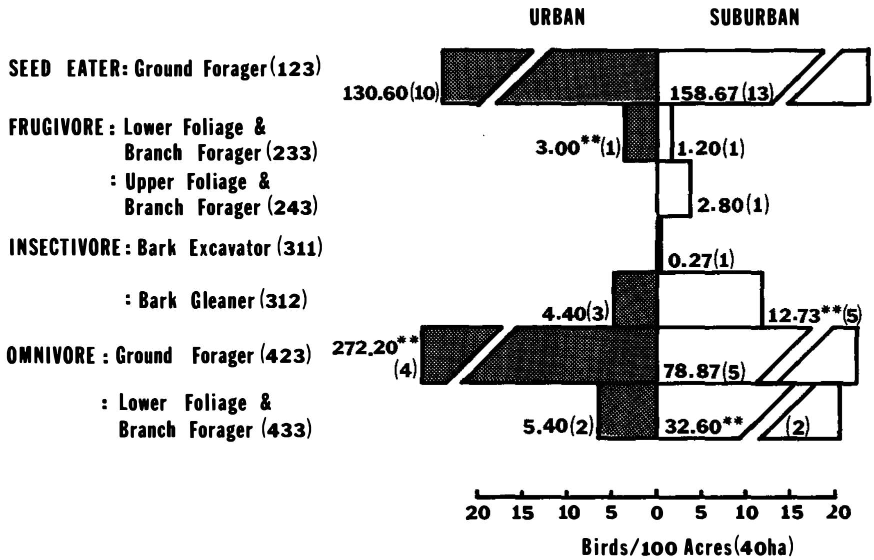

Figure 4. Winter foraging guilds in urban and suburban habitats. ( ) = number of species.

Table 3. Habitat variables significantly correlated with foraging guild densities in urban and suburban habitats.[a b c]

Guild	Breeding Season: Urban	Breeding Season: Suburban	Winter: Urban	Winter: Suburban
SEED EATER ground forager 123	aherb, wood lot scdrati	TDDIAM, TCDIAM sdnum, woodlot, NSPT SCDRATI	NO SIGNIFICANT CORRELATIONS	TDDIAM, TCDIAM, SCNUM, nhomes, amow, WOODLOT, NSPT tchtc, tdnum, TCHTC, tcnum, SCDRATI
FRUGIVORE lower foliage and branch forager 233			tdht, sdnum, nhomes scdrati	aherb, AMOW, woodlot TDHT, TDHTC, tdnum, tcdiam, TCHT, TCHTC, tcnum
FRUGIVORE upper foliage and branch forager 243		tdnum, sdht, SCDRATI tcdrati, nspt		amow
INSECTIVORE bark excavator 311				tdhtc, TCHTC amow, NSPT
INSECTIVORE bark gleaner 312	nhomes	TDHT, TDHTC, TDNUM, TCDIAM, TCHTC, TCHT, TCNUM SCNUM sdht, AMOW, woodlot, NSPT	tcnum	TDHT, TDHTC, TDNUM, TCDIAM, TCHT, TCHTC, SDNUM, SCNUM sdht, SCHT, AMOW, WOODLOT, NSPT
INSECTIVORE ground gleaner 322		TDHT, TDHTC, TDNUM, tcht, TCHTC, SCNUM tcdrati, AMOW, WOODLOT, NSPT		
INSECTIVORE lower foliage and branch gleaner 332	TCNUM, aherb SCNUM	TDDIAM, TDHT, TDHTC, TDNUM, TCDIAM, TCHT, TCHTC, tcnum, SDNUM SCNUM AMOW		

Table 3. (cont'd.)

Guild	Breeding Season: Urban	Breeding Season: Suburban	Winter: Urban	Winter: Suburban
INSECTIVORE upper foliage and branch gleaner 342		Above: tddiam, TDHT, TDHTC, tdnum, TCDIAM, TCHT, TCHTC, SDNUM, SCNUM Below: AMOW, woodlot		
INSECTIVORE air sallyer 354		Above: TDHT, TDHTC, TDNUM, tcht, TCHTC, TCNUM, SCNUM Below: SCHT, AMOW, WOODLOT, NSPT		
INSECTIVORE air screener 355		NO SIGNIFICANT CORRELATIONS		
OMNIVORE ground forager 423	NO SIGNIFICANT CORRELATIONS	Above: TDDIAM, tdht, TCDIAM, tcht, sdnum, TCDRATI NHOMES, WOODLOT NSP Below: TDNUM, tchtc, scdrati	Above: sdnum Below: SDHT scdrati, amow	Above: AMOW, WOODLOT, NSPT Below: TDHTC, TDNUM, TCHTC tcnum, scnum, SCDRATI
OMNIVORE lower foliage and branch forager 433		Above: tcht	Above: TDHT, SCNUM Below: sdht, scht	Above: TDHT, TDHTC, TDNUM, TCDIAM, TCHT, TCHTC, TCNUM, SDNUM, SCNUM Below: SDHT, SCHT, AMOW, WOODLOT, NSPT
OMNIVORE lower foliage and branch hover-gleaner 436		Above: tcdiam, tcht, sdht, SCDRATI, woodlot, nspt Below: scht, NHOMES		
OMNIVORE upper foliage and branch forager 443	Above: NSPT Below: SCHT	Above: TDHT, TDHTC, TDNUM, tcht TCHTC, SCNUM scdrati Below: AMOW WOODLOT NSPT		

[a] = Significance levels: Upper case = P < 0.01, lower case = P < 0.05.
[b] = Variables above diagonal line are positively related; those below are negatively related. Blanks indicate no guild members censused.
[c] = See Appendix II for variable names.

analyses. Over the five-year census, total breeding bird density increased by 22 pairs/100 acres, or 13.5 percent, when compared to values after two years' census. Winter density decreased by 18.3 birds/100 acres, or 6.4 percent.

Foraging guilds showing the greatest changes were insectivorous bark gleaners and lower foliage/branch gleaners, which increased during the breeding season over the five years, while winter occurrence of bark gleaners decreased slightly (Figures 1, 4 and 5). Ground foraging omnivores showed the greatest decrease in winter (Figures 4 and 5). The only guild to increase in winter density with the

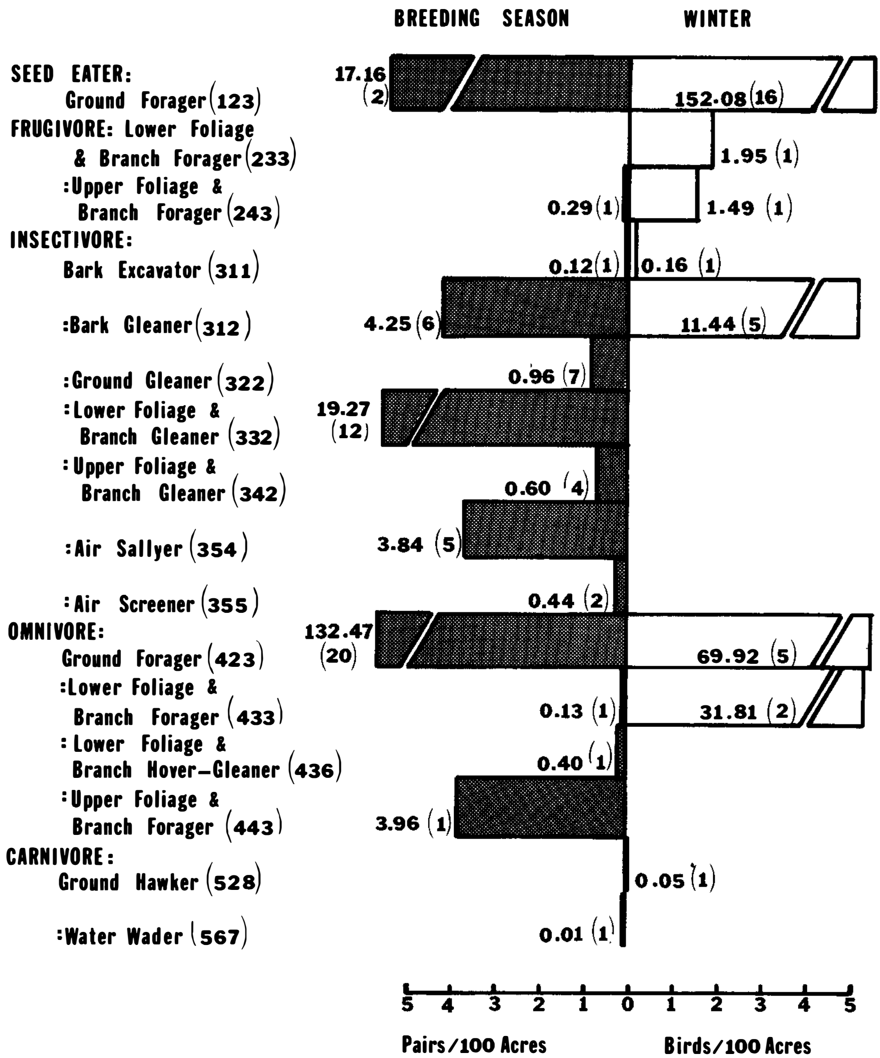

Figure 5. Composition of suburban foraging guilds in the breeding season and winter, Amherst, Massachusetts, 1975–1980. ( ) = number of species.

Table 4. Mean breeding and wintering density for birds in suburban Amherst, Massachusetts, 1975–1980.[a]

Species	Breeding density (Pairs/100 acres)	Winter density (Birds/100 acres)
Green heron	0.01	
Sharp-shinned hawk		0.05
Ring-necked pheasant	0.13	0.16
Rock dove		0.03
Mourning dove	8.15	17.09
Yellow-billed cuckoo	0.07	
Ruby-throated hummingbird	0.04	
Common flicker	0.76	
Pileated woodpecker	0.12	0.16
Hairy woodpecker	0.40	0.80
Downy woodpecker	0.92	2.05
Eastern kingbird	0.32	
Great crested flycatcher	1.40	
Eastern phoebe	0.97	
Least flycatcher	0.01	
Eastern wood pewee	1.17	
Tree swallow	0.21	
Barn swallow	0.23	
Blue jay	16.99	27.97
Common crow	0.77	0.59
Black-capped chickadee	6.09	27.57
Tufted titmouse	1.49	4.24
White-breasted nuthatch	2.36	7.76
Red-breasted nuthatch	0.28	0.40
Brown creeper	0.03	0.43
House wren	8.05	
Winter wren	0.01	
Mockingbird	3.35	1.95
Gray catbird	6.35	
Brown thrasher	0.11	
American robin	39.01	
Wood thrush	3.85	
Hermit thrush	0.03	
Swainson's thrush	0.03	
Blue-gray gnatcatcher	0.01	
Cedar waxwing	0.29	1.49
Starling	27.89	41.17
Solitary vireo	0.04	
Red-eyed vireo	1.88	
Warbling vireo	0.03	
Black-and-white warbler	0.32	
Blue-winged warbler	0.11	
Yellow warbler	0.37	
Yellow-rumped warbler	0.03	
Blackpoll warbler	0.09	
Ovenbird	0.08	
Common yellowthroat	1.00	

American redstart	0.17	
House sparrow	9.08	23.68
Eastern meadowlark	0.03	
Red-winged blackbird	0.45	
Northern oriole	3.96	
Common grackle	12.93	0.16
Brown-headed cowbird	0.23	0.83
Scarlet tanager	0.52	
Cardinal	5.51	5.11
Rose-breasted grosbeak	0.13	
Indigo bunting	0.08	
Evening grosbeak		35.52
Purple finch	0.01	1.57
House finch	2.08	5.31
Pine grosbeak		1.57
Common redpoll		0.05
Pine siskin		20.29
American goldfinch	1.39	17.84
Rufous-sided towhee	0.24	
Northern junco		9.28
Tree sparrow		6.88
Chipping sparrow	4.84	
Field sparrow	0.01	
White-throated sparrow		6.29
Swamp sparrow	0.03	
Song sparrow	7.32	0.53
	184.86	268.82

[a]n = 60 plots.

longer time interval was the lower-foraging frugivores, largely because of the increased success of mockingbirds in southern New England.

More pronounced changes can be seen in the nesting guild structure from 1975-77 versus 1975-79. Besides the occurrence of a nest parasite, the brown-headed cowbird, densities of all nesting guilds increased except those nesting in/on buildings, which declined 10 percent. Cavity nester density increased by 60 percent, ground/herb nesters by 44 percent, shrub nesters by 35 percent, tree twig nesters by 30 percent, and tree branch nesters by 7 percent (Figures 2 and 6). Three factors that likely explain these nesting guild density changes are: (1) the general maturing of the suburban vegetation over time, hence increases in ground, shrub, and tree twig/branch nesters, (2) the rapid decline of American elm (*Ulmus americana*) due to Dutch elm disease (hence increased use by cavity nesters), and (3) the possible decline in nest sites in or on buildings due to a general tightening of construction to conserve energy for home heating. Two of the dominant species of the building

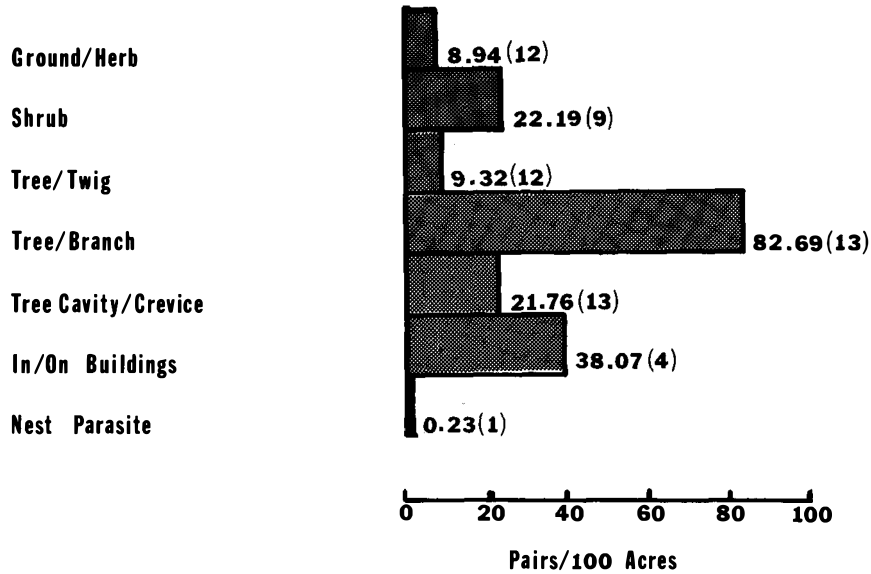

Figure 6. Composition of suburban nesting guilds, Amherst, Massachusetts, 1975–1979. ( ) = number of species.

nesting guild, the house sparrow and starling, also declined in winter occurrence (Tables 1 and 4).

The habitat associations of the foraging guilds are important management considerations. Examination of the columns of foraging guilds in Table 5 reveals several general patterns of habitat use. Most obvious is the strong association of all insectivores (except air screeners) to measures of tree cover, both in the breeding season and in winter; they also show an affinity for woodlots, being negatively correlated with the distance to the nearest woodlot. Seed eaters and omnivorous ground foragers were negatively associated with tree cover in winter, and were strongly associated with the area of weedy growth in the breeding season and with lawn area in winter. Both guilds were negatively associated with the nearest woodlot in both seasons (Table 5). Thus it would appear that insectivores and seed eaters or omnivores prefer different habitats in the suburb: insectivores of all foraging strategies except air screeners are associated with tree cover and natural stands all year; ground foraging seed eaters and omnivores utilize the more open areas—weedy areas in summer and yards in winter.

Conclusions

Two general problems plague urban wildlife researchers and managers, namely the lack of a standard scheme for grouping species and lack of habitat analyses that point up features that managers can actually manipulate. Although there are many studies in these problem areas, techniques have differed sufficiently, making it difficult to generalize about avian communities and management practices.

Table 5. Correlations between habitat features and foraging guild densities in suburban Amherst, Massachusetts, 1975–1980.[a–b]

	Breeding Season														Winter							
	123	243	311	312	322	332	342	354	355	423	433	436	443	567	123	233	243	311	312	423	433	528
TDDIAM	+	(+)			(+)	+				+									+		+	
TDHT		+		+	+	+	+	+	—				+		−	−		(+)	+	−	+	
TDHTC			(+)	+	+	+	+	+	(−)	(−)			+		−	−		+	+	−	+	
TDNUM			(+)	+	+	+	+	+	(−)	−			+		−	−			+	−	+	
TCDIAM	+	+		+	+	+	(+)		(−)	+		(+)							+	(−)	+	
TCHT		+		+	+	+	(+)	+	−			(+)	+						+	−	+	(+)
TCHTC			(+)	+	+	+	+	+	(−)	−			+		−	−		+	+	−	+	
TCNUM			(+)	+		+	+	+		(−)			(+)		−	−			(+)	−	+	
SDHT		+					(−)					(+)							(−)		−	
SDNUM	(+)				+	+				(+)									+		+	+
SCHT		−	−	(−)			(−)	−				(−)							(−)			
SCNUM	(−)		+	+		+	+	+		(−)			+		−	(−)			+	(−)	+	+
TCDRATI										(+)												
SCDRATI	−	+	+					+		−		+			−	−						
AHERB	(+)				(+)	(+)				(+)			(−)									
AMOW			−	−	−	−	−	−	+	+			−		+	+	(+)	−	−	+	−	
NHOMES		−								+		−			(+)	(+)						
WOOD LOT	(+)	(+)	(−)	−			−	−		+		(+)	−		+	+		(−)		+	−	
NSPT	+		(−)	−			(+)	−		+		(+)	−		+	(+)		−	(−)	(+)	(−)	
NSPS				+	(+)	+	(+)	+					+					(+)	+		+	(+)
TTNUM			(+)	+	(+)	+	+	+	(−)	−			+		−	−			+	−	+	
TSNUM				+	+	+	+	+					(+)						+		+	+

[a] = Correlations in ( ) are significant at $P \leq 0.05$; all others significant at $P \leq 0.01$.
[b] = See Appendix II for variable names.

We have tried to point up some of the major differences in urban and suburban avifaunas in New England. A striking difference is the lack of insectivores and ground nesters in urban habitats, clearly related to the lack of natural stands and secure open nesting habitat.

We suggest that the use of the concept of grouping species as "habitat associates" may be a useful way to get at the general relationships of avian community/habitat relationships. The open-ended aspect of this technique—which allows any number of nesting and foraging habits to be included—permits the construction of a fairly accurate scheme in terms of species' natural history.

We further suggest that two years of careful bird census work are sufficient for habitat analyses. Longer term studies allow better descriptions of the total avifauna, and are needed for detecting trends, especially as suburbs mature, but add little to total density.

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Appendix I. Scientific names and guilds.[a]

		Foraging		Nesting
		Breeding	Winter	
Green heron	*Butorides striatus*	567		2
Sharp-shinned hawk	*Accipter striatus*		528	
Ring-necked pheasant	*Phasianus colchicus*	423		1
Rock dove	*Columba livia*			
Mourning dove	*Zenaida macroura*			
Yellow-billed cuckoo	*Coccyzus americanus*	332		4
Ruby-throated hummingbird	*Archilochus colubris*			
Common flicker	*Colaptes auratus*			
Pileated woodpecker	*Dryocopus pileatus*	312		5
Hairy woodpecker	*Picoides villosus*			
Downy woodpecker	*Picoides pubescens*			
Eastern kingbird	*Tyrannus tyrannus*			
Great crested flycatcher	*Myiarchus crinitus*			
Eastern phoebe	*Sayornis phoebe*			
Least flycatcher	*Empidonax minimus*	354		4
Eastern wood pewee	*Contopus virens*			
Tree swallow	*Iridoprocne bicolor*			
Barn swallow	*Hirundo rustica*	355		6
Blue jay	*Cyanocitta cristata*			
Common crow	*Corvus brachyrhynchos*			
Black-capped chickadee	*Parus atricapillus*			
Tufted titmouse	*Parus bicolor*			
White-breasted nuthatch	*Sitta carolinensis*			
Red-breasted nuthatch	*Sitta canadensis*			
Brown creeper	*Certhia familiaris*			
House wren	*Troglodytes aedon*			
Winter wren	*Troglodytes troglodytes*	322		5
Mockingbird	*Mimus polyglottos*			
Gray catbird	*Dumetella carolinensis*			

Appendix I. (cont'd.)

		Foraging		Nesting
		Breeding	Winter	
Brown thrasher	*Toxostoma rufrum*			
American robin	*Turdus migratorius*			
Wood thrush	*Hylocichla mustelina*			
Hermit thrush	*Catharus guttatus*			
Swainson's thrush	*Catharus ustulatus*			
Blue-gray gnatcatcher	*Polioptila caerulea*	342		4
Cedar waxwing	*Bombycilla cedrorum*			
Starling	*Sturnus vulgaris*			
Solitary vireo	*Vireo solitarius*	342		3
Red-eyed vireo	*Vireo olivaceus*			
Warbling vireo	*Vireo gilvus*			
Black-and-white warbler	*Mniotilta varia*	312		1
Blue-winged warbler	*Vermivora pinus*			
Yellow warbler	*Dendroica petechia*			
Yellow-rumped warbler	*Dendroica coronata*	332		4
Blackpoll warbler	*Dendroica striata*			
Ovenbird	*Seiurus aurocapillus*			
Common yellowthroat	*Geothlypis trichas*			
American redstart	*Setophaga ruticilla*			
House sparrow	*Passer domesticus*			
Eastern meadowlark	*Sturnella magna*			
Red-winged blackbird	*Agelaius phoeniceus*			
Northern oriole	*Icterus galbula*			
Common grackle	*Quiscalus quiscula*		123	
Brown-headed cowbird	*Molothrus ater*	423		7
Scarlet tanager	*Piranga olivacea*			
Cardinal	*Cardinalis cardinalis*			
Rose-breasted grosbeak	*Pheucticus ludovicianus*			
Indigo bunting	*Passerina cyanea*	332		1
Evening grosbeak	*Hesperiphona vespertina*			
Purple finch	*Carpodacus purpureus*	423		3
House finch	*Carpodacus mexicanus*			
Pine grosbeak	*Pinicola enucleator*		123	
Common redpoll	*Carduelis flammea*		123	
Pine siskin	*Carduelis pinus*			
American goldfinch	*Carduelis tristis*			
Rufous-sided towhee	*Pipilo erythrophthalmus*			
Northern junco	*Junco hyemalis*			
Tree sparrow	*Spizella arborea*			
Chipping sparrow	*Spizella passerina*			
Field sparrow	*Spizella pusilla*			
White-throated sparrow	*Zonotrichia albicollis*			
Swamp sparrow	*Melospiza georgiana*			
Song sparrow	*Melospiza melodia*			

[a]Guild designations provided for species not included in Table 1.

Appendix II. Mnemonics and variables used as habitat descriptors.

Mnemonic	Variable
TDDIAM	Deciduous tree DBH
TDHT	Deciduous tree height
TDHTC	Deciduous tree height to crown
TDNUM	No. deciduous trees
TCDIAM	Coniferous tree DBH
TCHT	Coniferous tree height
TCHTC	Coniferous tree height to crown
TCNUM	No. coniferous trees
SDHT	Deciduous shrub height
SDNUM	No. deciduous shrubs
SCHT	Coniferous shrub height
SCNUM	No. coniferous shrubs
TCDRATI	Coniferous:deciduous tree ratio
SCDRATI	Coniferous:deciduous shrub ratio
AHERB	Area of "weedy" growth
AMOW	Area of lawn
NHOMES	No. dwellings
WOODLOT	Woodlot distance
NSPT	No. tree species
NSPS	No. shrub species
TTNUM	Total number of trees
TSNUM	Total number of shrubs

The Role of Feeding Stations in Managing Nongame Bird Habitat in Urban and Suburban Areas

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Introduction

The United States is a highly urbanized society. These urbanites enjoy more leisure time and are becoming more involved with nature-related activities (Davey 1967). In fact such activities as nature walks, bird watching, nature photography, and bird feeding are becoming more popular than ever (National Audubon Society 1973), and are one of the main reasons why some urbanites are moving to the suburban counties. It has been estimated that approximately 20 percent of American households buy an average of 60 pounds (27.2kg) of birdseed each year (DeGraaf and Payne 1975). Total birdseed sales for 1974 were estimated at $170 million (DeGraaf and Payne 1975).

The amount of artificial bird feeding being conducted in the United States gives it great potential as a tool in managing urban wildlife populations (Thomas et al. 1973). Paulick (1976) and Gehringer (1980) both found feeders influenced bird distribution in winter. However, a greater overall understanding of artificial bird feeding is necessary if this tool is to be utilized properly.

The objectives of this study were to:

A. List the numbers and species of birds that visit feeders and relate these data to:
   1. environmental and residential zone
   2. average daily use and timing of feeder utilization
   3. average seasonal use and timing of feeder utilization
   4. temperature and precipitation
   5. social behavior and movements.

B. Postulate effects of feeders on urban bird populations and their management.

C. Determine food preferences of birds which visit feeders.

Study Areas

Four locations in the area of State College, Pennsylvania, were chosen to represent the following environmental and residential zones:

1. wooded residential
2. wooded planned community
3. non-wooded apartment complex
4. open field, non-residential.

Each study site consisted of a 10-acre (4-ha) square plot centered on a feeder location.

A report (#6287 of the Pa. A.E.S.) on Project 2448 of the Pennsylvania Agricultural Experiment Station. Research was supported by McIntire-Stennis, USFS Consortium for Environmental Forestry Studies, and Agway Inc.

Wooded Residential

The wooded residential study area was characterized by singlefamily houses, many of which were over 50 years old. The area was once hilly farmland, and perhaps had never been plowed. Today it has returned to a mature stand of oak (*Quercus* spp.), hickory (*Carya* spp.), and black cherry (*Prunus serotina*), especially so in the old farm fencelines with oaks up to 54″ DBH (137.2cm). Among these buildings and mature hardwoods were planted shrubs and small trees, mostly dogwoods (*Cornus florida*), and evergreens in backyards and along streets. Herbaceous ground cover was over 90 percent lawns and planted gardens. Paved areas were limited to one two-lane highway and several side streets. At least five other feeders in the area were active during winter months. One edge of a mature oak parkland of about 15 acres (6 ha) was within 133 yards (122m) of the feeders.

Wooded Planned Community

The wooded residential study area was characterized by single-family houses, many of which were over 50 years old. The area was once hilly farmland, and (*Pinus* spp.), and aspen (*Populus* spp.). The understory consisted mostly of dogwoods, aspen, and maple (*Acer* spp.). The only exposed ground cover was a lawn area in the immediate vicinity of the feeders. The only paved areas were two small parking lots of about 0.25 acre (0.1 ha) located on the opposite side of the apartment building from the feeder location. There were at least three other feeders active during the winter within the study area.

Non-Wooded Apartment Complex

The non-wooded apartment complex was characterized by two four-unit two-story apartment buildings built on an old farm field. There were several mature staghorn sumacs (*Rhus typhina*), and one approximately 30-foot red oak (*Quercus rubra*). Approximately 40 percent of the study area consisted of a cornfield and about 20 percent was open lawn. The remaining 40 percent of the study area was covered by buildings and pavement. There were two small parking areas totaling 0.2 acres (0.08 ha), and one heavily traveled two-lane highway. There were no other active feeders in the immediate area, and the nearest woodlot was approximately 440 yards (400 m) from the feeder location.

Open Field, Non-Residential

The open field, non-residential study area was an agricultural field planted to hay. One small stand of young black cherry trees about 9 feet (2.7 m) tall occupied 0.05 acre (0.02 ha) toward one edge of the field. The primary vegetative cover was tall grasses, predominantly timothy (*Phleum pratense*). The entire study area was bisected by a five-foot (1.6 m) barbed-wire fence, and the nearest wooded area was approximately 165 yards (150 m) from the feeder location. The feeder was located along the fenceline in the center of the field.

Methods

The four study areas were each supplied with three tubefeeders of approximately a four-pound (1.8 kg) capacity, depending on the feed. One feeder at each station was supplied with a mix, one with thistle (Niger), and one with sunflower seed (test feeds 1, 2, and 3, respectively, in Table 1). The study was conducted from January 1979 through March 1980, but data were not collected at the wooded planned community and the non-wooded apartment study sites during the summer.

Observations

Day-long observations (sunrise to sunset) were conducted at least once during each month of the study period at all four sites simultaneously when possible. Data recorded included the number and species of birds visiting each of the feeders, along with the time and duration of stay. In addition, the weight of each feed consumed was measured at the end of each observation day. Also, daily and seasonal use were determined from the measurements of total use during each month.

Weather

Temperature (daily highs and lows) and precipitation (solid and liquid) data were obtained from The Pennsylvania State University Department of Meteorology.

Bird Distribution

At the wooded residential site, birds were live-trapped and color-banded in an effort to determine the effects of feeders on local bird numbers and distribution.

Table 1. Foods tested for preference among birds.

Bird foods
1. Feathered Friend Mix (70% white millet, 15% milo, 5% red millet, 5% sunflower, 3% cracked corn, 2% wheat)
2. Thistle (Niger)
3. Confectionary sunflower
4. Oil sunflower
5. Sunflower meats
6. Birdsnack Mix (40% white millet, 20% cracked corn, 15% wheat, 13% sunflower, 5% peanut hearts, 5% hulled oats, 2% canary seed)
7. Flyers' Choice Mix (90% sunflower meats, 10% peanut hearts)
8. Oats
9. Canary seed
10. Red millet
11. White millet
12. Cracked corn
13. Peanut hearts
14. Wheat
15. Suet
16. Peanut butter
17. Fruit (banana, apple, pear, orange)
18. Bread
19. Suet cake
20. Snack-cake (suet mix)
21. Suet box

From February 22 to March 10, 1980, five censuses were conducted at this study area. Census method was to walk the entire 4 ha area surrounding the feeder site and to record and plot all birds seen.

Food Preferences

From December 10, 1979 to February 29, 1980, a detailed food preference study was conducted at the wooded residential study site. Twenty-one feeds (Table 1) were offered both on the ground and in hanging feeders. Use was measured at the end of each day to determine overall preference. Day-long observations were conducted on five different days to determine individual species preferences as measured in bird-minutes. All of the 14 seed grains (feeds 1-14 in Table 1) were analyzed for nutrient content by The Pennsylvania State University Department of Animal Science.

Statistical Analysis

The diversity of bird species observed at each of the four study-sites was determined by the Shannon diversity index (Zar 1974). Daily use values were simply totaled and reported as daily averages for each feed at each study-site (Table 2). Correlation analyses (Steel and Torrie 1960) were conducted to determine relationships between consumption and weather, and between food preference and nutrient content. The Student-Neuman-Keuls test (Zar 1974) was used to determine significance of food preferences.

Results

Diversity

The two wooded areas showed considerably greater bird species diversity than the non-wooded areas but the results were not statistically significant. In order of decreasing diversity, the study areas were: wooded residential, wooded planned community, open field non-residential, and non-wooded apartment complex.

Feeder Use

Use was heaviest at the wooded planned community but only the non-wooded apartment complex was notably lower (Table 3). The most numerous bird species was the American goldfinch (*Spinus tristis*) (Table 4), with the house finch (*Carpodacus mexicanus*) a close second.

Daily use began shortly before sunrise, reached a peak about two hours later, and leveled off for most of the day before gradually tapering off toward sunset. There was variation among the different species. Some birds, like the house finch, followed the above pattern of daily feeding. However, the evening grosbeak (*Hesperiphona vespertina*), for example, often fed only from late morning until early afternoon.

Use was generally heaviest during the summer, but the study areas varied considerably. Also, these summer data reflect use at only the wooded residential

Table 2. Average daily use for each species at each study site. Values in bird-minutes. Includes ground feeding birds.

Species	Station			
	Wood resid.	Wood. plan. comm.	Non-wood apts.	Open-field non-resid.
Mourning dove	52.5	0	0	3.4
Hairy woodpecker	1.4	0	0	0
Downy woodpecker	7.3	0	0	0
Red-bellied woodpecker	0.1	0	0	0
Blue jay	4.9	13.0	0	0.4
Common starling	55.2	0	0	0
Brown-headed cowbird	0.8	0	0	0
Redwinged blackbird	0	0	0	3.9
Common grackle	52.3	0	0	27.4
Evening grosbeak	144.2	278.4	0	0
Purple finch	0	16.3	0	2.2
House finch	1214.9	580.1	377.0	2390.5
American goldfinch	1562.2	3224.2	4778.0	26.5
Pine siskin	2.3	0.8	0	0
White-throated sparrow	27.0	1.9	0	0
Tree sparrow	0	129.0	0	0
Dark-eyed junco	65.4	508.5	0	0
Song sparrow	7.4	51.6	0	0
Rufous-sided towhee	0	21.0	0	0
Common cardinal	15.3	18.2	0	0
House sparrow	299.0	0	0	237.7
Gray catbird	1.2	0	0	0
Carolina wren	0.9	0	0	0
White-breasted nuthatch	14.2	0	0	0
Tufted titmouse	3.2	3.3	0	0
Black-capped chickadee	0	8.0	0	0
American robin	0.9	0	0	0

Table 3. Average daily consumption; all feeds, grams.

Station	Use
Wooded planned community	777
Open field, non-residential	654
Wooded residential	623
Non-wooded apartment complex	294

Table 4. Birds observed; bird-minutes/day at hanging feeders.

Species	Use
American goldfinch	1310
House finch	1229
House sparrow	147
Evening grosbeak	89
Common grackle	9

and open field non-residential study sites. Use at the wooded residential study area was heaviest in late spring-early summer and lowest in early winter. Use at the wooded planned community was heaviest in late winter and lowest in early fall. There were no data for the summer at this site. Feeder use at the open field, non-residential site was heaviest in mid-summer and lowest during the winter. Use at the non-wooded apartment complex was heaviest in winter and and lowest in the fall. There were no data for summer at this site. Seasonal feeding habits varied considerably among different species. Most species fed only during the winter, but several species were active at feeders during the entire study period.

Weather

There was no significant correlation ($P>0.05$) between total daily use and either temperature or precipitation. Use was highest during the presence of snow cover and lowest during periods of heavy rainfall and wind. Light wind or rain did not appear to have any effect on feed consumption.

Effect of Feeders on Bird Distribution

Bird feeders had a considerable effect on local bird numbers and distribution. Over 75 percent of all birds sighted during the bird censuses were within approximately 50 feet (15 m) of a bird feeder, only 20 percent of the census area.

Food Preference

Sunflower "chips" or meats was the most highly preferred food over all ($P<0.05$), followed by oil sunflower seed, confectionary sunflower seed, "Flyers' Choice" mix (90 percent confectionary sunflower meats, 10 percent peanut hearts), and thistle (Niger seed), respectively (Table 5). There were no significant differences ($P>0.05$) among the other 16 foods tested. Individual species preferences were evident and are reported in Table 6.

Table 5. Average daily consumption (grams) and four statistically significant preference ratings.

Food	Use	Rating
Sunflower meats	82.1	A
Oil sunflower seed	64.4	B
Confectionary sunflower seed	52.6	BC
"Flyers' Choice" Mix	44.6	C
Thistle (Niger)	36.7	C
All others	10.5	D

Table 6. Individual species preferences (* - preference significant).

Species	Preferred food
House finch	Sunflower meats
American goldfinch	Thistle (Niger)*
White-breasted nuthatch	"Flyers' Choice"*
Black-capped chickadee	Peanut butter
Tufted titmouse	Oil sunflower*
Downy woodpecker	Suet*
House sparrow	"Flyers' Choice"
Carolina wren	Peanut hearts*

Nutrient Content

The proximate analysis of the seed grains tested showed that feeder use was significantly positively correlated with gross energy, ether extract, and crude protein content of feed. There was a significant negative correlation ($P<0.05$) between use and nitrogen free extract. These same trends were reflected in some individual species' preferences, but statistically significant in only a few. No signficant correlations were found for percent dry matter, crude fiber, and ash.

Discussion

Literature Review

For most urban dwellers, the best opportunity for enjoying wildlife-related activities is observing non-game birds (DeGraaf and Payne 1975). Birdfeeding is the only "direct-natural" contact with wildlife (More 1977) that many of these people encounter, and therefore may be their best wildlife education activity. Perhaps the greatest educational value found in birdfeeding is the diversity of wildlife that may be observed while feeding birds.

Species diversity has often been cited as one of the goals of wildlife management (Alexander 1962). Gehringer (1980) found that as a community becomes older, its vegetative components become more complex, and bird species diversity becomes greater. Geis (1974) found that a residential community where some original trees were retained had a higher species richness than an otherwise similar treeless area. Paulick (1976) found that natural wooded areas left unchanged in a planned community yielded a greater bird species diversity than the non-wooded areas of the community by providing a more diverse and complex vegetative structure. He also found that local areas of a residential complex can increase bird species diversity and population density with artificial feeding if a "pool" of species exists in the surrounding areas. Thomas et al. (1973) and Dennis (1978) also found that feeders increased bird species diversity.

Diversity

This study also found that a wooded area has a higher bird species diversity than a non-wooded area. As stated, the relatively old and complex wooded areas are more diverse vegetatively, and therefore they yield a greater diversity of bird species. Individual species data for the non-wooded apartment complex were lacking at this site, so comparisons, especially those based on diversity, should be made with some caution.

Feeder Use

Though the study areas reflected differences in species diversity, feeder activity patterns were very similar. Bird activity in general is usually greatest at or near sunrise and sunset (Welty 1975), but these patterns were not reflected in feeder use. These patterns could reflect food availability, but may also indicate that social species may take time to form their flocks. If little food is available, the individual may obtain more energy with less effort in a flock which may be more apt to find a food source. With the abundance of food found at a feeder, an individual may consume food more leisurely while expending a minimum of energy, and therefore it may feed for as much time as it wants. However, this does not explain these same trends in summer feeding.

Feeding was found to be heaviest in the summer, with generally fewer species but more individuals of each species present. This heavy feeding may in part be the result of the young of those few species feeding along with the adults, and in part due to the longer daylight period. This heavy feeding in summer reflects primarily the pattern of two species—the house finch and the house sparrow (*Passer domesticus*). Since this heavy summer feeding reflects results at only the wooded residential and open field non-residential sites, comparisons with other seasons must be made with some caution.

Weather

There was no statistically significant correlation ($P>0.05$) between feeding and either temperature or precipitation in this study. Grey (1976) found that feeding decreased in good weather, but her study was limited to the winter months, and summer feeding patterns apparently reflect the opposite. Seasonal correlations were not computed in this study. There was an apparent positive relationship between feeding and the presence of snow cover. This may simply reflect the unavailability of natural foods and therefore increase dependence upon the artificial food source. There was also an apparent negative relationship between feeding and heavy rain, though light rain appeared to have little effect. Grey (1976) also observed this situation. Wind also appeared to have a negative effect on feeding, apparently by making feeding from a hanging feeder very difficult.

Effect of Feeders on Bird Distribution

The presence of feeders appeared to have a considerable effect on local bird distribution and numbers. This is simply an abundant food source attracting an abundance of birds. Once a few birds had located a food source, their presence may have helped attract more birds to that food source. The same individually marked birds were spotted repeatedly on successive days, reflecting a tendency to travel little and conserve energy in the winter.

Food Preference

Sunflower meats was the most preferred food overall, and the top four feeds were at least 90 percent of some form of sunflower seeds. Grey (1976) also found sunflower to be preferred by more species than any other food, though its total consumption was second to millet. A release by a wild bird food distributor (Agway 1973) also indicates sunflower to be preferred by more bird species than any other food. Geis (1980) found that the small black oil-type sunflower seeds were superior to the striped types. He also found that the white proso millet was preferred among small seed-eating species. This great preference for sunflower could be tied to either gross energy content or crude protein content or both. Both nutritive components were found to be significantly correlated ($P<0.05$) with feeder use. However, energy has been noted as the most important item in an animal's diet (Church and Pond 1975).

Summary

With an ever-increasing urban population there is an even greater need for the understanding of wildlife in these urban areas. The management goal of diversity can be achieved by having wooded habitat and artificial bird feeding. Birds are active at artificial feeders most of the day and almost all year, and may be enjoyed at almost any time. Weather apparently affects bird feeding, but these effects were not proven statistically in this study. Bird feeders were shown to have a considerable effect on bird distribution in winter. Most birds prefer some form of sunflower seed, and this preference is linked with the energy and protein content of this seed.

Future Research Needs

Food preferences should be studied more closely to determine any geographic differences in preference within certain species. Some birds should be marked for easy identification and observed to determine the effect of feeders on territories and home ranges. Dominance and other social behavior should be observed in more detail. More attention must be paid to the design and relative location of bird feeders and the effects these may have on feeding. Finally, the overall effects of feeders on natural selection must be closely scrutinized—that is, are some species becoming more dependent upon feeders, and are others which don't utilize feeders being selected against?

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Values of Urban Wildlife in Missouri

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Introduction

One of the most novel challenges accepted by the wildlife profession in recent years is managing for wildlife in the city. This topic has received considerable attention over the last decade (Leedy 1979), but the task remains uncustomary in at least two ways. First, most wildlife species are managed by agency personnel in rural settings which have grown reassuringly familiar to wildlife professionals. The idea of plying the wildlife trade in the world of high-rises and suburbia is one with which most wildlifers are not overly comfortable. Second, conventional wisdom holds that wildlife management is most productive when conducted far removed from metropolitan environments and large concentrations of people. Spending time and money to manage wildlife in urban areas is thus an unusual allocation of resources.

This lack of familiarity raises important questions. In what ways do urbanites value wildlife? How many are involved in wildlife-related activities in urban settings? And most intriguing, is it possible that managing urban wildlife can be as beneficial to wildlife conservation as wildlife management in rural areas? These questions persist in spite of recent studies and commentary offering some answers (e.g., Brown et al. 1979, Leedy et al. 1978, Shaar 1979).

A unique opportunity to contribute to our growing understanding of urban wildlife values exists in Missouri. The citizenry has expressed its support for conservation of the state's fish, wildlife, and forests in an unprecedented way. Missouri voters approved a constitutional amendment in 1976 adding one-eighth cent to the state sales tax to provide funding for an expanded conservation program called Design for Conservation (Brohn 1977). The amendment carried most heavily in urban areas. Among other goals, "Design" seeks to respond to the wildlife-related interests of the 2.5 million residents of St. Louis (1.5 million), Kansas City (.8 million) and Springfield (.2 million). These people constitute 52 percent of all Missourians. Evidence that these citizens are "urbanites" is the fact that they are concentrated in about 1 percent of the state's 68,995 square miles (178,697 km^2).

A survey of adult residents in these three cities was funded by the Missouri Department of Conservation in 1980 to gain clues useful in serving the urban citizenry. Specific objectives were to determine (1) the nature-oriented activities of urban Missourians, (2) the attitudes of urban dwellers toward wildlife in the city, and (3) the likelihood of urban residents using certain nature-oriented facilities and services if available in or fairly near urbanized areas. This paper reports the results of the study.

Methods

Technical aspects of the survey were divided between the Missouri Department of Conservation and a private firm selected by the Department following competitive bidding. The questionnaire was written by staff of the Department, while the Opinion Research Division of Fleishman-Hillard, Inc., St. Louis, Missouri ("The Missouri Poll") pretested the questionnaire, suggested revisions, and completed 1,520 telephone interviews. The consultant conducted the survey in January 1980 using a sample of Missouri telephone households in St. Louis (487 interviews), Kansas City (527 interviews), and Springfield (506 interviews). To avoid systematic sampling bias, telephone numbers were randomly generated, calls were made in the evenings and on weekends, up to four calls were made to each household, and prospective respondents were screened by sex and age (18 and older). Not only did the respondents provide information about their interests, but on certain questions, were asked to give information about the characteristics and activities of all their household members. The average length of interview was 13 minutes. Respondents in 62 percent of the eligible households contacted completed interviews. Results for each city were weighted by population and combined to yield the three-city percentages which follow.

Results

Nature-oriented Activities

Of three general types of recreation—(1) outdoor activities, (2) reading or watching TV, and (3) sports—"outdoor activities like hunting, fishing, and bird-watching" were the recreational pursuits most enjoyed by 26 percent of urban adults. Not surprisingly, nearly twice as many (47 percent) indicated "reading or watching TV" held most appeal. Twenty-four percent most enjoyed "sports you take part in like playing tennis, softball, and bowling." Three percent had no preference.

A related question asked respondents how many people in their households participated in each of 23 nature-oriented activities (Table 1). The desire was to count not only those people who participated in the past several years, but those who consider themselves participants but have not been involved lately. The results generally were in line with those of a recent national survey which assessed participation using a similar rationale (Kellert 1980). Exceptions were the percentages for "museum or zoo visit," "watching birds," and "nature photography." Definitions for these items varied substantially between the national study and this urban survey.

The nature-oriented opportunities most readily available to urbanites were those with the largest number of participants. In the three-city area, seven activities had participation greater than 50 percent. "Watching programs on TV about the outdoors" had highest involvement (80 percent), followed closely by "visiting museums or zoos" (78 percent). "Going for a pleasure drive to enjoy the scenery" ranked third (69 percent) and was the only activity in the top seven which might require travel out of the cities. Two wildlife activities with majority involvement were "feeding birds or other wildlife near home" (59 percent) and "taking time to watch birds or other wildlife near home" (53 percent). The finding that "feeding

Table 1. Percentage of participation in nature-oriented activities by all household members.

Abbreviated activity description	St. Louis	Kansas City	Springfield	Three-Cities	United States[a]
Nature TV viewing	76	84	89	80	78
Museum or zoo visit	80	77	77	78	46
Drive to enjoy scenery	66	73	73	69	
Neighborhood walk	64	67	75	66	
Feed birds near home	55	66	64	59	68
Read about nature	50	56	67	53	49
Watch birds near home	49	57	70	53	25
Fishing	45	53	59	49	44
Camping	47	46	58	48	
Outdoor gardening	39	49	54	43	
Boating	40	43	53	42	
Hiking	40	39	45	40	
Gathering nuts/greens	27	34	43	30	
Nature photography	26	29	30	27	42
Canoeing	27	23	26	25	
Hunting	18	21	26	20	25
Target firearms	14	17	17	16	
Gathering mushrooms	9	26	16	15	
Tending fish aquarium	10	18	13	13	
Backpacking	13	13	14	13	13
Target archery	8	7	9	8	
Membership in groups	6	10	10	8	11
Trapping	1	1	1	1	2

[a]Data from Kellert 1980

birds'' had more participants than ''watching birds'' suggests that a few urbanites provided what they considered to be wildlife food but did not take time to watch the wildlife which might be drawn to the food.

Participation in the 16 remaining activities fell below 50 percent, though practically one-half (49 percent) indicated fishing experience. Three other activities were wildlife-related: ''nature photography,'' defined as photographing wildlife, wild flowers, trees or other natural things (27 percent); ''hunting'' (20 percent); and ''trapping'' (1 percent).

For most outdoor activities, the proportions of young participants (15 years old and less) were roughly comparable to the proportions of older participants. Two notable exceptions were ''hunting,'' in which 9 percent of the youngsters were involved compared to 23 percent of older urbanites, and ''firearms target shooting,'' with 7 percent of the youngsters involved and 18 percent of those 16 years and older.

Proportionally, more whites than blacks participated in nature-oriented activities. Participation reported for household members by the 146 black respondents was still substantial, however, e.g., nature TV viewing (64 percent), feeding birds (45 percent), watching birds (38 percent), fishing (32 percent), nature photography (17 percent), and hunting (8 percent). A comprehensive explanation for higher involvement by whites than blacks is beyond the scope of this paper. One contributing factor might be that 66 percent of the white respondents had backgrounds which were ''suburban, small town, or country,'' while 65 percent of the black respondents had "urban" backgrounds. Opportunities for blacks to develop nature-oriented interests may have been less than for whites.

On a percentage basis, Springfield generally had the largest number of participants in nature-oriented activities, followed by Kansas City, and then St. Louis. Again, background of respondents might help account for these differences in interest. Forty-three percent of those from Springfield had "country or small town" backgrounds, compared to 28 percent of Kansas Citians, and 16 percent of St. Louis respondents having such backgrounds.

Attitudes Toward Urban Wildlife

Thirteen percent of the survey respondents in the three-city area had wildlife-related problems around their residences in the last several years. For those people reporting problems, squirrels were most often the cause (42 percent), followed by skunks (25 percent), birds (22 percent), moles (16 percent), rabbits (15 percent), and raccoons (11 percent). Fifty-nine percent of the urbanites affected were unable to take care of the problems; only 27 percent felt that the Missouri Conservation Department could have helped solve the problem.

Despite the foregoing, it seems clear that urban dwellers view wildlife in the city as an asset and not a liability. Ninety-three percent of the respondents in the three-city area described the wild animals around their homes as "enjoyable" rather than "pests." In a related question, 72 percent said they were satisfied with the number of opportunities to observe wildlife near their homes. The 28 percent remaining, however, represents thousands of urban Missourians interested in improving chances to see wildlife around their residences.

Interest in Urban Services and Facilities

Present Use. Substantial percentages of urbanites were aware of selected services and facilities of the Missouri Conservation Department. For example, 23 percent of the households contacted in the three-city area received the Department's free monthly magazine, *Missouri Conservationist.* In 1979, 31 percent of the St. Louis respondents said that at least one household member visited the August A. Busch Memorial Wildlife Area located on the edge of metropolitan St. Louis. During the same year, 26 percent of the Kansas City respondents indicated that at least one household member visited the James A. Reed Memorial Wildlife Area on the outskirts of Kansas City. And in 1979, fully 50 percent of the Springfield respondents said that at least one household member visited a Missouri Conservation Department exhibit or live animal pavilion at a sports show or fair. This finding is explained by the presence of the Department's extensive and popular exhibit at the annual Ozark Empire Fair near Springfield.

The survey provided clues as to whom the Department's programs might be missing. Sixty-one percent of black respondents were "not at all familiar" with the Missouri Conservation Department, compared to 33 percent of white adults "not at all familiar." Thirty-one percent of the black adults said they were "not at all interested" in Missouri's wildlife, fish, and forests, compared to 17 percent of white respondents saying "not at all interested." And on a proportional basis, the *Missouri Conservationist* magazine was received by substantially more white households (26 percent) than black households (9 percent).

Likely Use. A number of questions explored the likelihood of urbanites using nature-oriented services and facilities if available in or fairly near the urban areas. Admittedly, these expressions of interest probably would exceed involvement if the services actually were provided. In the three-city area, 33 percent of the respondents said it was likely that at least one household member would take a course in "water safety," as did the same percentage for a course on "plants, animals, and trees in Missouri." Twenty-two percent responded favorably to a course on "fishing," as did 18 percent for a "backpacking" course, and 17 percent for a "hunting" course. On a proportional basis, more blacks than whites were likely to take courses to learn outdoor skills.

Likely visitation by at least one household member also was estimated for "a community lake or pond near home" (62 percent), "a nature center offering programs and exhibits on Missouri fish, wildlife, and forests" (54 percent), and "a bank fishing area along the Mississippi, Missouri, or James River" (41 percent). The level of interest in these facilities was high; and well this is, in order for expenditures for such capital improvements to be given serious consideration.

Finally, respondents were asked to express approval or disapproval of conducting outdoor nature study programs in cemeteries where there is open space and cover for wildlife. Sixty-two percent in the three-city area approved of using cemeteries for nature study.

Discussion

These survey results showing high awareness and enjoyment of urban wildlife by Missourians are strikingly similar to those from a study of New York urbanites (Brown et al. 1979), a study of Colorado residents (SRI Community Response of Colorado, Inc. 1977), and a recent survey of the U.S. population (Kellert 1980). The similarities have important implications for widening the political and financial base of wildlife management. Sportsmen have long been recognized as the principal benefactors of wildlife conservation, but agencies are experiencing inflationary strains which make broadening the base of support appealing. Encouraging a conservation coalition between nonhunting wildlife enthusiasts and sportsmen is a feasible alternative (Shaw and King 1980). However, the general public represents the firmest base on which wildlife conservation could stand, and it is the public which has volunteered its monetary support of conservation in Missouri.

If urban Missourians are like other urban and state populations in the ways they value wildlife, might not other populations be like Missourians in their willingness to make a commitment to wildlife conservation? The commitment need not be in the form of a self-imposed tax. Other approaches exist, such as the state income tax check-off with which several states are having success, notably Colorado (Wildlife Management Institute 1980).

State wildlife agencies need not be reluctant to consider new funding sources in this era of heightened government frugality. Budgets for wildlife conservation have always been lean. Agencies have achieved success under this condition, but additional support is now required to maintain present wildlife-related services, much less enhance them. Moreover, social research (Kellert 1979) and experiences in Missouri, Colorado, Oregon, and elsewhere have shown that the product which wildlife agencies offer is one for which a substantial part of the general public will voluntarily pay. In this sense, wildlife conservation seems not to be the unwelcome burden which some government programs might represent to the public.

Most Missouri urbanites did not view the funding of Design for Conservation as an unreasonable expense, as evidenced by their supporting votes. This can be attributed, in part, to the Conservation Department's long-standing commitment to providing programs and facilities in or near urban centers. Since 1957, conservation service coordinators and support personnel have been located in St. Louis and Kansas City, and since 1972, in Springfield. Prior to these dates, Conservation Agents of the Department promoted the agency's programs in urban areas through various media and by providing a variety of conservation-related services and information which today are better known as urban forestry and urban wildlife management.

Revenues from the Conservation Sales Tax have allowed the agency to intensify urban efforts and give greater visibility to the Department and its programs. For example, two urban biologists hired as a result of the Conservation Tax furnish urban wildlife information to local government agencies, land developers, the media, and private citizens in the two largest metro centers, St. Louis and Kansas City. A St. Louis fishing program started in 1969 has been expanded (Alcorn 1980), while such a program was initiated in Kansas City in 1978 (Jeffries 1980). Both have proven extremely popular with urban fishermen—no small group in view of the survey results—and have provided many minority youngsters their first angling experiences. Moreover, two management biologists were hired to oversee the urban fishing programs, as well as provide technical advice and assistance on other fisheries in the St. Louis and Kansas City areas. A habitat inventory has been completed for Kansas City, showing where opportunities remain for wildlife management, e.g., in parks, in cemeteries, and along streams, green-belts, boulevards, and parkways. In Springfield, nongame species have been given heightened attention, exemplified by a grant from the Conservation Department to the Dickerson Park Zoo to help support a breeding program for bald eagles *(Haliaeetus leucocephalus)*. And statewide, an Urban Wild Acres program has been established which involves acquisition of natural areas readily accessible to urbanites.

Increased funding also has allowed the Department to give heightened attention to fostering wildlife and nature appreciation in future generations of Missourians. This is a particularly important task in light of the survey results which showed participation differences in selected outdoor activities on the basis of race and age. Outdoor education might be the most effective means of reaching urbanites who may be growing isolated from nature-oriented experiences because of social and economic conditions.

One approach taken by the Conservation Department to stimulate wildlife and outdoor appreciation is the distribution of conservation education packets to school teachers involved with kindergarten through grade eight. These are sent statewide three times a year, each packet containing materials addressing several conservation concepts using instructional techniques appropriate for the grade being taught. More than 4,000 teachers receive packets in the St. Louis, Kansas City, and Springfield area.

A second approach is to teach outdoor skills to adults who then can instruct youngsters. Such is the responsibility of the Department's seven Outdoor Skills Specialists, three of whom are based in the urban centers. With the aid of comprehensive instructional materials prepared by the Department, prospective instructors receive training in shooting sports, casting and angling, backpacking, outdoor cooking, and map and compass. Approximately 100 schools in the three-city area have outdoor education courses in their curricula. Many instructors of these classes have been trained by the Skills Specialists.

Of course, the most direct way urbanites can become aware of wild animals is by seeing wildlife. No doubt, encounters with larger game species in urban environments can add spice to life and, under certain circumstances, might be promotable. In an experimental program, for example, wild turkeys *(Meleagris gallopavo)* were released in 1979 in Kansas City, Missouri. They have fared well, increasing their numbers and moving beyond the release sites via habitat corridors.

Much more usual, however, are backyard experiences like "feeding" and "watching" birds, which the survey showed to be among the most common wildlife-related activities of urbanites. "Backyard Wildlife" is a slide program developed by the Conservation Department's urban biologists for presentation to neighborhood and civic organizations. The show illustrates wildlife habitat needs, methods to provide these needs around home, and the benefits of providing wildlife habitat to the urban dweller. The program highlights methods which can attract what might be considered the more desirable and entertaining species, like songbirds, small mammals, butterflies, and lizards. However, common urban wildlife like pigeons, sparrows, and starlings are not demeaned, for such animals provide satisfying wildlife encounters for some urbanites.

High concentrations of people and limited habitat belie the potential for urban wildlife management to yield conservation benefits. By providing wildlife-related opportunities in these places, urbanites' awareness and enjoyment of wildlife can be enhanced. Moreover, their political support might be stimulated and maintained. The relatively novel task of urban wildlife management could thus become a key element of wildlife conservation in the 1980s and beyond.

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Wildlife in the Chicago Area: the Interaction of Feeding and Vegetation

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Introduction

Bird feeding in North America is a large retail industry involving millions of households (Payne and DeGraaf 1975). Popular books are available to inform the novice about proper wildlife feeders and seed mixtures (Dennis 1975, McElroy 1977). Attraction of birds and other wildlife through appropriate trees and shrubs has been encouraged by the National Wildlife Federation. Many popular books describe how to create backyard wildlife habitat (Bourne and MacConomy 1974, DeGraaf and Witman 1979, Gellner et al. 1975, Terres 1953) with vegetation in addition to artificial feeding. These books emphasize the variety of wildlife that can be attracted through feeders and the planting of vegetation in backyards.

The variety of wildlife in the city of Chicago is limited, however. A majority of Chicago residents find only house sparrows *(Passer domesticus)*, rock doves (pigeons) *(Columba livia)*, or an occasional gray squirrel *(Sciurus carolinensis)* at their feeders. For approximately one-third of the residents of the Chicago Metropolitan Statistical Area, the attraction of wildlife to backyards is limited to less than 10 species. This fact suggested the purpose of this study: To what extent is success in attracting wildlife by feeding influenced by the surrounding habitat? This paper independently examines the importance of vegetation and feeding to the wildlife community, followed by an analysis of the interaction of these two factors.

Methods

The study areas selected for this paper included a series of urban and suburban neighborhoods of the Chicago Metropolitan Statistical Area. The neighborhoods ranged from the Chicago Loop (almost no vegetation) to Lake Forest (a wooded suburb) and Addison, Illinois (an unwooded suburb). Vegetation was quantified by the average density of large, deciduous trees taller than 25 feet (7.6 m). This simple index was the best single variable to describe habitat quality in a Chicago area analysis of urban bird communities (Guth 1980). The neighborhood names, followed by the large, deciduous tree densities, included: Chicago Loop (0 trees per acre, 0 trees/ha), North Central Chicago (8.9 trees per acre, 21.9 trees/ha), South Evanston (13.9 trees per acre, 34.4 trees/ha), North Evanston (22.0 trees per acre, 54.4 trees/ha), Wilmette (20.5 trees per acre, 50.6 trees/ha), Winnetka (41.1 trees per acre, 102 trees/ha), Lake Forest (25.8 trees per acre, 63.9 trees/ha), Skokie (12.0 trees per acre, 29.7 trees/ha), and Addison (5.9 trees per acre, 14.6 trees/ha). Detailed locations and descriptions of these study areas are available in Guth (1980).

The segment method for urban areas (Schemnitz 1980: 229) was used throughout this study. A sample coverage of a segment included a four-minute count of all birds and mammals seen or heard using the segment. Sample coverages of a study area usually began within 30 minutes of sunrise in summer and in the morning hours during winter. I sampled between 8 and 24 segments (100 yards by 100 yards each, 91.4 m by 91.4 m) within each study area in January 1975, June 1975, January 1976, June 1976, and January 1977. Because of the diurnal nature of these counts, wildlife in this paper is confined to diurnal birds and mammals. The number of active feeders or feeding sites was recorded during the segment counts. The number of large, deciduous trees taller than 25 feet was separately recorded for each segment. I later computed large deciduous tree density per acre from the tree densities within segments.

The results of segment counts provided data to analyze the overall impact of vegetation and feeding on wildlife. I used the densities of large, deciduous trees and of feeders or feeding sites within segments as indices for vegetation and feeding impacts. I partitioned wildlife density into components of native and exotic species in order to examine the effect of feeding. Exotic species observed in this study were rock doves, starlings (*Sturnus vulgaris*), and house sparrows. The number of wildlife species, the density of native wildlife, and the density of exotic wildlife were correlated with vegetation and feeding in order to determine overall effects of vegetation and feeding on wildlife. Summer and winter results were analyzed separately.

In a second analysis, I sorted the segment results into separate categories based on (1) the presence or absence of feeding in the segment and (2) whether the segment contained more or less than 30 large, deciduous trees (14.52 trees per acre, 35.88 trees/ha). I examined means and computed statistics from these results in order to evaluate the effect of vegetation in the presence or absence of feeding, and the effect of feeding in the presence or absence of vegetation. These results allowed an examination for potential interactions between feeding and vegetation in the Chicago area.

In a final analysis of the impact of feeding, I recorded from the above field data the identity of species observed at feeders and the densities of wildlife found in segments with feeders. These results allowed a further evaluation of the interaction between feeding and vegetation.

Results

Overall trends

The number of all species and the density of native wildlife were significantly correlated with vegetation in summer. The number of wildlife species increased significantly with large, deciduous tree density ($r = 0.66$, $p < 0.01$ for 16 degrees of freedom). The summer density of native wildlife also increased significantly with tree density ($r = 0.72$, $p < 0.01$). The summer density of exotic wildlife was uncorrelated with tree density ($r = 0.03$). In winter although the number of all species increased with greater tree density, there were no significant correlations between tree density and wildlife densities or the number of wildlife species.

The density of all wildlife was significantly correlated with feeder density in winter ($r = 0.55$, $p < 0.01$ for 24 df). This trend was largely due to the significant correlation between the density of exotic wildlife and feeder density ($r = 0.58$, p

<0.01). The average winter density of exotic wildlife in segments with feeders was 15.1 animals, compared to 4.5 animals in segments without feeders. The average winter density of native wildlife was 0.8 animal in segments with feeders and 0.5 animal in segments without feeders. The number of wildlife species did not significantly change with the density of winter feeders. In summer there were no significant correlations between feeder density and wildlife density or the number of wildlife species. There were fewer wildlife species in segments with summer feeders (5.0 species in areas with feeders compared to 14.6 species in areas without feeders), although this trend may be related to the placement of feeders in areas with less vegetation. There was also a greater density of exotic wildlife in segments with summer feeders (17.7 animals per segment compared to 7.5 animals per segment without feeders).

In both summer and winter, wooded segments contained more feeders than unwooded segments. A shift occurred in the placement of feeders between summer and winter, however. A greater percentage of segments with feeders were located in wooded suburbs in winter than in summer, because residents in wooded suburbs were less likely to continue the feeding of wildlife into the summer. There was a significant negative correlation between feeder density and tree density in summer ($r = -0.50$, $p < 0.05$ with 16 df), but no correlation in winter ($r = -0.11$).

Effect of Vegetation in the Presence or Absence of Feeding

In segments with feeders, the number of species was significantly correlated with tree density in summer ($r = 0.69$, $p < 0.05$ with 8 df), and the densities of all wildlife and exotic wildlife were significantly negatively correlated with tree density in winter (both $r = -0.63$, $p < 0.05$ with 13 df). In the presence of feeders, the density of native wildlife generally increased and the density of exotic wildlife generally decreased with greater tree density in both summer and winter (Table 1).

Table 1. Summer and winter wildlife parameters sorted by (1) the presence or absence of feeders in the segment, and (2) whether the segment contained more or less than 30 large deciduous trees. Standard deviations are given in parentheses.

	Sample size[a]	Number of wildlife species	Density of native wildlife[b]	Density of exotic wildlife[b]
Summer				
Feeders, wooded	6	6.0(3.0)	6.8(4.4)	13.0(7.9)
Feeders, unwooded	7	4.4(1.9)	4.1(3.5)	20.2(23.9)
No feeders, wooded	12	16.4(9.2)	6.4(3.5)	8.2(3.2)
No feeders, unwooded	14	9.4(4.7)	5.5(5.0)	7.1(2.7)
Winter				
Feeders,wooded	11	3.8(2.4)	1.6(2.4)	13.7(10.9)
Feeders, unwooded	13	2.5(1.3)	0.5(0.7)	16.0(6.8)
No feeders, wooded	9	4.6(2.7)	0.5(0.3)	4.0(3.5)
No feeders, unwooded	14	3.1(1.6)	0.6(0.6)	4.5(3.6)

[a]Sample size is based on number of study areas and seasons sampled.
[b]Density is given in animals per segment (100 yards by 100 yards, 91.4 m by 91.4 m).

The winter number of wildlife species was uncorrelated with tree density in the presence of feeders ($r = 0.10$). The only significant correlations with tree density were indicated above.

In segments without feeders, the number of all species was also significantly correlated with tree density in summer ($r = 0.66$, $p < 0.01$ with 16 df), and the density of all wildlife, as well as the density of native wildlife, was significantly correlated with tree density in summer (all wildlife $r = 0.81$, $p < 0.01$, and native wildlife $r = 0.74$, $p < 0.01$). The summer density of exotic wildlife increased slightly with tree density in the absence of feeders. There were no significant correlations between tree density and winter wildlife in the absence of feeders. The winter number of wildlife species generally increased and the winter density of exotic wildlife generally declined with tree density in the absence of feeders (Table 1).

Effect of Feeding in the Presence or Absence of a Large Number of Trees

In segments with many trees, the number of all wildlife species was significantly negatively correlated with the density of feeders in summer ($r = -0.57$, $p < 0.05$ with 12 df). The density of all wildlife and particularly the density of exotic wildlife was significantly correlated with feeder density in winter (all wildlife $r = 0.82$, $p < 0.01$ with 10 df, exotic wildlife $r = 0.83$, $p < 0.01$). Slight trends included a greater density of exotic wildlife with feeder density in summer wooded segments, and fewer species but more native wildlife with feeder density in winter wooded segments (Table 1).

In segments with few trees, the density of exotic wildlife was significantly correlated with the density of feeders in summer ($r = 0.71$, $p < 0.01$ with 12 df) and in winter ($r = 0.57$, $p < 0.05$ with 12 df). Although the density of all wildlife significantly grew with winter feeder density in the absence of trees ($r = 0.57$, $p < 0.05$), there was a general trend toward fewer species and a lower density of native wildlife with summer feeder density in segments with few large trees (Table 1).

Effect of Feeding on the Wildlife Community

Feeding was more important to wildlife in the more urban, less wooded settings. In both summer and winter, there was a significant decline in the percentage of wildlife species using feeders as the tree density increased (summer $r = -0.86$, $p < 0.01$ with 7 df, winter $r = -0.79$, $p < 0.05$ with 6 df). In the Chicago Loop, 67 percent of summer species and 100 percent of winter species utilized feeding. In North Central Chicago, 46 percent of summer species and 100 percent of winter species used feeders. In Lake Forest and Winnetka, there were no summer feeders, and winter species utilizing feeders were 56 percent and 25 percent of the observed species respectively. Feeders created a greater impact on the density of exotic wildlife in unwooded areas. In summer the density of exotic wildlife was 2.8 times greater in unwooded segments with feeders, but only 1.6 times greater in wooded segments with feeders than without feeders. In winter the density of exotic species was 3.6 times greater in unwooded segments with feeders, but 3.4 times greater in wooded segments with feeders than without feeders. Segments with feeders in winter accounted for a greater percentage of individuals in unwooded areas, as follows: Chicago Loop, 41 percent of individuals were found in segments with feeders; North Central Chicago, 85 percent; South Evanston, 54 percent; Skokie, 59 percent; Addison, 66 percent; compared to Wilmette, 57 percent; Winnetka, 8 percent; Lake Forest, 40 percent. In summer the importance of feeders was more pronounced for unwooded urbanized areas, as follows: Chicago Loop, 41 percent of individuals were found in segments with feeders; North Central Chicago, 51 percent; South Evanston, 19 percent; Skokie, 25 percent; compared to Wilmette, 13 percent; Addison, 4 percent; and North Evanston, Winnetka, Lake Forest, 0 percent each.

Discussion

Results of this report suggest an interaction between feeding and vegetation affecting Chicago wildlife. This interaction includes both the effect of feeding and vegetation on wildlife, and different levels of feeding by citizens of urban and suburban neighborhoods. The discussion below focuses on the Chicago area, where exotic species comprise over 90 percent of the winter wildlife and about 60 percent of summer wildlife. The conclusions below should not be generalized to other metropolitan areas without careful examination of the local wildlife present in other areas. For example, in Maryland there are more native species in winter, and this difference might significantly alter the conclusions derived from the Chicago area (Geis, pers. comm.).

Wildlife in this study responded to vegetation rather than to feeders in summer. Segments with increased tree density contained significantly more species and a greater density of native wildlife. Exotic wildlife were not affected by increased tree density, and the presence of feeders did not significantly alter summer populations.

Wildlife in the Chicago area responded to feeders rather than to habitat in winter. The density of exotic wildlife was significantly correlated with feeder density. Native wildlife probably also benefited from the presence of feeders in winter. The amount of vegetation did not significantly affect winter wildlife densities.

Urban citizens followed a different pattern of feeding than did suburban residents. Feeding of wildlife was popular in winter throughout the study areas, but only urban citizens continued a high level of feeding during summer. Suburban dwellers seldom fed wildlife in summer, probably because they could enjoy abundant wildlife attracted by vegetation. Urban dwellers continued feeding throughout the year, utilizing bread crumbs, bird seed, and popcorn scattered on the ground as well as traditional feeder strucutres.

Given that a site contained a high density of large trees, feeding did not significantly increase wildlife in summer. Feeding probably increased the density of exotic wildlife but reduced the variety of species. Feeding in winter significantly increased the density of exotic wildlife and may have benefited native species, but it did not increase the number of species observed.

Given that a site contained a low density of large trees, feeding significantly increased the density of exotic wildlife in summer, but probably decreased the density of native wildlife and variety of species. The competitive dominance of exotic species may have contributed to this decline. Feeding in winter in the absence of vegetation also significantly increased the density of exotic wildlife, but did not alter the density of native wildlife or the variety of species.

Given that a site contained feeders, increased levels of vegetation significantly increased the variety of species in summer. Native wildlife were slightly more abundant and exotic wildlife were slightly less abundant with increased vegetation in summer. In winter, increased levels of vegetation significantly decreased the density of exotic wildlife in the presence of feeders. Native wildlife probably benefited, although the variety of species was unchanged.

A different set of circumstances applied to sites without feeders, for increased levels of vegetation significantly increased both the variety of species and the density of native wildlife in summer. Exotic wildlife may have also increased in density. Increased vegetation in winter without feeding did not significantly alter the wildlife population, although there was a tendency to increase the variety of species and decrease the density of exotic wildlife.

The strategy for the maximum variety of species and maximum density of native wildlife in the Chicago area differs with the season. Increasing the amount of available vegetation, along with accompanying shrubbery, will benefit wildlife the most. It is better to avoid feeding of wildlife during the summer if variety and native wildlife density is desired. Feeding in winter will benefit native wildlife, but feeding in neighborhoods with low levels of vegetation will largely benefit exotic wildlife such as house sparrows or rock doves. Increased levels of vegetation are needed in order to benefit native wildlife by winter feeding.

The Chicago urban wildlife community was much more dependent on feeding than the suburban wildlife community. A high percentage of species and individuals in urban neighborhoods were dependent on year-round feeding. Exotic wildlife particularly benefited. This dependence on feeders declined in suburban locations, especially in summer. The potential species that could be attracted by a feeder also declined in the central urban areas. In the Chicago Loop, rock doves and house sparrows were the only species observed at winter feeding sites. In Skokie, winter feeders attracted house sparrows, rock doves, and dark-eyed juncos *(Junco hyemalis)*. In suburban Lake Forest, winter feeders attracted house sparrows, starlings, cardinals *(Cardinalis cardinalis),* black-capped chickadees *(Parus atricapillus),* and downy woodpeckers *(Dendrocopos pubescens)*. A feeder placed by a winter resident of Chicago did not attract as many species as a similar suburban feeder would attract. Although the variety of wildlife attracted to an urban feeder is lower, the overall importance of feeders to wildlife in urban settings far exceeds the importance of feeders in suburban settings.

Conclusions

A significant interaction between feeding and vegetation affects the wildlife of the Chicago area. Increased levels of vegetation benefit native wildlife in summer, but both feeding and vegetation are important for native winter wildlife. Suburban residents tend to feed wildlife in winter such that native species are benefitted. In urban neighborhoods of the central city, however, residents feed wildlife through the year. The high level of feeding in the urban center, coupled with the low level of vegetation, serves to promote exotic wildlife such as house sparrows, starlings, and rock doves. Success in attracting native wildlife is limited by the absence of vegetation in the urban areas.

Two recommendations are suggested by this report. (1) Programs to promote urban wildlife should consider urban needs separately from suburban needs. Especially important for cities such as Chicago are programs to develop increased vegetation for wildlife throughout the city. To simply encourage the feeding of wildlife without increasing vegetation will frequently cause frustrated citizens who find only house sparrows and rock doves at their feeders. Alternately, such feeding also causes frustration for government officials who find large numbers of rock doves overrunning parks and buildings. (2) Research in other sections of the country has occurred and should be further encouraged to test the applications of this urban need. Small towns in the Northeast, large cities in the South, and cities in the deserts of the West probably have very different use of feeding and vegetation by wildlife.

Acknowledgements

E. Raymond Heithaus and Aelred D. Geis provided important encouragement during the collection of data for this study. I thank Northwestern University for financial support during the period of field research. Data used in this report were collected during research leading to a Ph.D. thesis at Northwestern University.

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Activities of Gray Squirrels and People in a Downtown Washington, D.C. Park: Management Implications

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Introduction

Wildlife studies in the downtown sections of our cities are lacking. Previous work concentrated on public health problems associated with commensal rodents, feral dogs and pigeons and starlings. Few efforts were undertaken to document activities and relationships of wildlife in metropolitan centers. Such topics as practical strategies to encourage or discourage wildlife in the highly urbanized sections of the city and the factors that private, municipal and federal administrators should consider when establishing programs and policies affecting downtown wildlife were not addressed.

Lack of information on these issues became apparent in 1977 to the managers of Lafayette Park, a national park in downtown Washington, D.C., after unsuccessful attempts had been made to resolve a gray squirrel *(Sciurus carolinensis)* problem. In late spring and early summer of that year, gray squirrels in this park reportedly destroyed 2,000 geraniums and damaged six newly planted trees, worth about $4,500. An overpopulation of squirrels, said to be greater than 12.5 squirrels/acre (31.25/ha), was blamed for the problem. Following these incidents, the park staff began to relocate park squirrels to areas outside the city with the hope that this would reduce damage to park vegetation. The relocation program was halted due to adverse criticism from local citizens and animal protection groups and subsequent news media coverage.

At this point a study was undertaken to document the habits of the park squirrels to help the Lafayette Park management staff alleviate future squirrel damage to park vegetation. Previous urban gray squirrel investigations had been conducted only in suburban or cemetery environments (for example, Robinson and Cowan 1954, Thompson 1977a) and virtually no ecological information was available on squirrels inhabiting downtown areas. This paper describes initial results from this study on the squirrels' food habits, activities and interactions with the public and discusses biological and social considerations relating to their management.

Study Area

Lafayette Park, an 8.2 acre (3.3 ha) park located across Pennsylvania Avenue from the White House, is surrounded by four major streets lined with multi-storied buildings on three sides. Sidewalks around the perimeter and in the park comprise 34 percent of the area. Approximately 50 percent of the park is manicured turf. Two main vegetational layers exist—large trees underlain with grass. A few shrubs, young trees and five large statues create a third structural layer in some sections of the park. Flower beds comprise 6.3 percent of the area. There are two 0.06 acre (0.02 ha) water fountains at opposite ends of the park. The topography is flat.

The 191 trees and shrubs in the park consist of 30 native and exotic species. The dominant tree and shrub species and their relative abundance in the park are: willow oak *(Quercus phellos)* 24.6 percent; magnolia (*Magnolia* sp.) 16.2 percent; American elm *(Ulmus americana)* 16.2 percent; ginkgo *(Ginkgo biloba)* 6.3 percent; horsechestnut *(Aesculus hippocastanum)* 3.7 percent; and northern red oak *(Quercus rubra)* 2.6 percent. Also present are trees typically found in other urban settings, such as little and big leaf linden (*Tilia* sp.); green and Korean ash (*Fraxinus* sp.) and Japanese pagoda *(Sophora japonica)*. Three formally landscaped shrubs, Japanese holly *(Ilex rotundifolia)*, yew *(Taxus* sp.) and azalea *(Azalea grantiflora)* were also in the park.

Though willow oak is the most abundant species, 87 percent are less than 8 inches (20.3 cm) DBH and 78 percent are street trees. The remaining 15 oak trees (four species) are old enough to produce good fruit crops as are the elms.

Park personnel usually removed potentially hazardous tree limbs, dead or diseased that could have been utilized as squirrel dens, but 26 nest boxes had been distributed in the park in 1969 and 1977. Garbage is collected daily from open trash receptacles around mid-afternoon, however some refuse often remains in the containers until the next pickup.

Other park wildlife includes pigeons *(Columba livia)*, starlings *(Sturnus vulgaris)*, house sparrows *(Passer domesticus)*, gulls (mainly *Larus delawarensis*), rats *(Rattus norvegicus)*, and occasional crows *(Corvus brachyrhynchos)*, blue jays *(Cyanocitta cristata)*, cardinals *(Richmondena cardinalis)* and mockingbirds *(Mimus polyglottos)*.

Methods

Estimation of Abundance

Squirrel density was estimated by two or more observers simultaneously walking through an equal area of the park in the same direction and counting squirrels that they passed. This count of all squirrels visible at a given time was a minimum estimate of the total population. This estimate was probably close to the actual population as park squirrels were highly curious and visible. Squirrels were counted between 0500–0830 and 1600–1930 hours, when temperatures were above 0°C, and when wind and precipitation were negligible.

Activity

Food habits and activity patterns of squirrels were studied by following individual squirrels for 15 minute intervals between sunrise and sunset from April through October, 1980. At the start of each sampling period, the third squirrel sighted in randomly determined quadrants became the focal animal. This reduced the probability of studying only the most visible animals. A total of 782 focal animals were proportionately observed over each month and in daylight hours.

Every item wholly or partially consumed by focal animals during the 15 minute periods was noted. The identity of food items (plant species and structure) were documented; quantity of food was not recorded. Results were analyzed by month according to the relative use of particular items.

Each occurrence of the following squirrel activities during a 15 minute time interval was tabulated: feed; forage (behavior associated with searching for food); store (behavior associated with burying food); rest (sleeping and loafing); groom (scratching, licking and biting oneself or another squirrel); chase (behavior associated with the pursuit and/or flight from another squirrel or squirrels); movement (other locomotion not used in the above categories); other (other behavior not described in the above categories). Data were analyzed by two hour periods from sunrise to sunset. Activity indices show the percentage of squirrels engaged in each of the above activities during each time period.

Squirrels stripping, gnawing, peeling or ingesting bark were recorded during observations of focal animals. General location of the damage, tree species, and if possible sex and age of offending squirrels were recorded.

Tulips and geraniums were monitored to record wildlife damage. Six plots, each with 100 tulips, and four plots, each with 50 geraniums, were checked weekly for leaf and flower damage. Comparison plots were inspected, at locations elsewhere in the city, where few or no gray squirrels lived.

Squirrel movements between Lafayette Park and adjacent areas were recorded by periodically watching the four streets surrounding the park in early mornings and late afternoons. Occasionally we walked between Lafayette Park and three adjacent parks, all within three city blocks of each other, to look for moving squirrels.

Leaf nests were tallied in Lafayette Park each month. Since it was difficult to determine active nests, only those nests with a general tight spherical shape and large enough to house an adult squirrel were counted.

Instances of park visitor-wildlife interactions were recorded, especially squirrel-human encounters. Food items offered and the time of day were noted. Personal discussions with some of these people provided additional information regarding their park wildlife activities and interests.

Reference to time in this paper is always Eastern Standard Time. Results described below were obtained between March–November 1980.

Results

Population Estimates

Squirrel population estimates were computed using the largest number of squirrels seen and recorded during counts within a month. The Lafayette Park squirrel density ranged from 9.1 squirrels/acre (22.75/ha) in March to 20.6 squirrels/acre (51.5/ha) in November. The highest number of squirrels observed during counts increased 47 percent between March and May and 56 percent between August and November. These increases were largely due to the appearance of young squirrels born in the late spring and summer. No change was evident in the largest number of squirrels counted in May and August.

Activity Patterns

During April and May, 281 squirrels were observed. A median of 42 (range 28-53) focal animals were watched during each of the 7 two-hour periods used in the data analysis.

All activity categories during the two months, except rest, showed bimodal activity patterns, with peaks generally occurring between 0500–0700 and 1700–1900 hours (Figure 1). The rest activity category exhibited a unimodal pattern with over 70 percent of the focal animals resting between 1100–1500 hours. Squirrels became active within one hour of sunrise. Their first behavior was self-grooming, followed by foraging and feeding. In the evening, squirrels usually foraged until approximately one hour after sunset, at which point they moved into the trees for the night.

During June, July and August, 410 squirrels were watched. A median of 59 (range 49-67) focal animals were observed in each of the 7 two-hour periods used in the analysis.

Patterns and peaks of activity during these three months were similar to those in spring (Figure 1). However, in summer, squirrels were active earlier and began their midday inactivity sooner than in spring. Between 0500–0700 hours, 80 percent of the summer focal animals engaged in five or more activity categories per 15 minute period, compared to 66.5 percent of the spring squirrels. Between 0700–0900 hours, approximately 39 percent of the summer focal animals were observed in less than five activity categories compared to 25 percent of the squirrels in the spring. There were no apparent differences between the proportion of focal animals in the spring and summer engaged in five or more activity categories during 1700–1900 hours (75 percent and 77 percent, respectively).

During summer midday inactivity periods, squirrels rested at heights lower than in the spring or fall, often on the lowest branches of trees, sometimes only five feet (1.5 m) above ground. Squirrels frequently sprawled out on the ground at the base of trees with legs outstretched. Resting squirrels were easier to locate in the summer as they tended to sleep and loaf outside their nests.

During October, 91 squirrels were followed for 15 minutes each. A median of 20 (range 15–21) focal animals were observed in each of the 5 two-hour periods used in the analysis.

During October, daily activities were not as sharply confined to distinct time periods as in spring and summer (Figure 1). For example, squirrels were as likely to be found foraging and feeding during midday as during the morning and afternoon. Squirrels also tended to be more active during October than in other months. In October, 48.3 percent of the focal animals stored food items at least once during 15 minute intervals compared to only 13.9 percent in spring and 18.7 percent in summer. There were also greater occurrences of movement during October (90 percent) than in spring (62.5 percent) and summer (66.3 percent). Increased non-resting activity in October made squirrels more conspicuous in the park at all times of the day.

Some activities were not restricted to specific times. Mating chases, as described

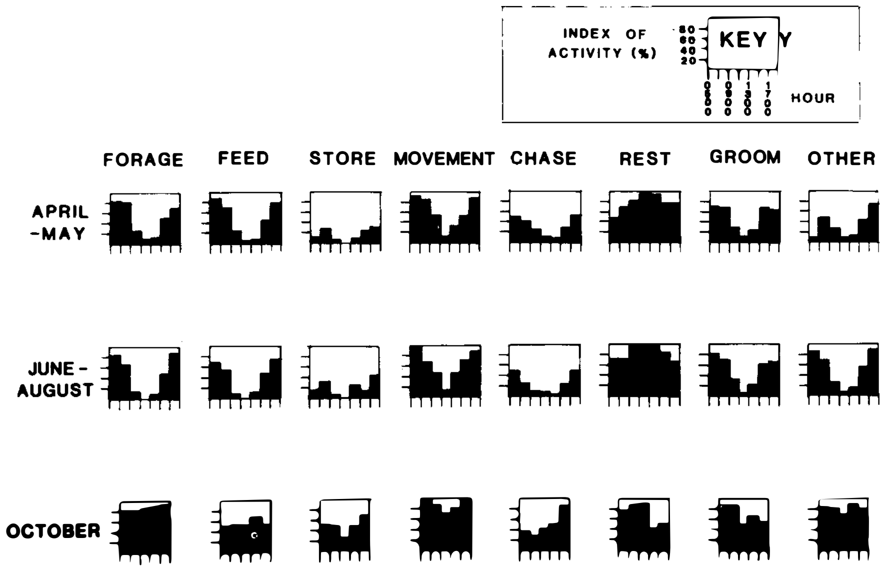

Figure 1. Activity patterns of the Lafayette Park squirrels according to three seasonal periods (observations in October were conducted between 0700–1700, others were between 0500–1900).

by Baaken (1959) and Thompson (1977a), were seen at all hours, and lactating females foraged in May and August during all daylight hours.

Movements

All four streets bordering Lafayette Park were traversed by gray squirrels. The north, east and west streets were crossed more frequently than the wider and busier Pennsylvania Avenue to the south. Squirrels crossed streets mainly before the morning rush hour and after the evening rush hour. The extent of movements across streets is illustrated by observations made on one day (May 9, 1980), when 11 different squirrels were observed crossing streets between 0545 and 0715 hours (sunrise 0600). Prior to and while crossing streets, squirrels typically flicked their tails, sat up, remained motionless and ran in a crouched manner.

Movements to and from the park were of two types. Most commonly squirrels living adjacent to Lafayette Park entered the park for daily use of its resources. These squirrels appeared to move at will across the surrounding streets. The other kind of movement appeared related to the dispersal or emigration of squirrels from surrounding areas. This was demonstrated in the early summer, when a black-colored squirrel was seen in Lafayette Park for the first time during our study. After six weeks it disappeared.

Gray squirrels traveled between the scattered downtown city parks and evidently moved large distances. One adult squirrel was followed one morning for 20 minutes, as it traveled at least two city blocks from a 1.5 acre (0.6 ha) park to Lafayette Park—a journey of nearly 0.3 mile (0.48 km).

Leaf Nests

Prior to leaf emergence in early May, leaf nests were usually successfully built only in evergreens, primarily in three boxwood shrubs (*Buxus sempervirens*) and in a large fir (*Abies* sp.) tree. During late winter and early spring, some squirrels attempted to make nests of deciduous tree twigs, mainly oaks, but these usually fell apart.

After foliage appeared, the number of leaf nests increased from 60 in May to 139 in July and then steadily decreased to 15 in November. The number of tree and shrub species containing leaf nests also followed a similar pattern. Most leaf nests between May-November were in American elms, willow oaks, pin oaks (*Quercus palustris*), white oaks (*Quercus alba*), English elms (*Ulmus procera*) and bald cypress (*Taxodium distichum*). However the American elm and willow oak were the two most abundant trees, whereas only a few of each of the other species were in the park.

The location of leaf nests seemed unrelated to human activities within the park. At least four nests were found in trees bordering streets, two of which overhung the street. Many nests were low to the ground and in very small trees. One leaf nest was located in a pin oak only 12 feet (3.6 m) above a park sidewalk that was heavily used by the public. At least four of the leaf nests found in willow oaks between June–November were in trees with a median DBH of only 4.8 inches (12.2 cm) and median height of 25 feet (7.6 cm).

More than one leaf nest in a tree was common. One pin oak contained six nests and another had five. American elms and willow oaks typically had one nest per tree; however one American elm contained ten leaf nests for three months and one willow oak contained 12 in July and 11 in both August and September.

In addition to using twigs and leaves for nest material, squirrels used newly planted sod, tissue paper, newspaper, cloth and cellophane. Leaf nests were also located across the streets bordering the park. Squirrels using these nests commonly crossed into Lafayette Park to feed and forage.

Food Habits

Squirrel feeding activities were observed 349 times on 519 food items (Table 1). Foods identified as supplemental were obtained from park visitors either directly as handouts or indirectly from refuse. Squirrels consumed virtually all oak acorns before they fell to the ground. Therefore it is assumed that acorns found buried by squirrels originated from supplemental food.

Peanuts, a supplemental food, were the most important food throughout the study accounting for 35 percent of all items eaten. Acorns, English walnuts, chicken bones, peach and plum pits, apples and bread were other supplemental foods and collectively comprised 10 percent of the total observed diet. The remaining portion of the total diet contained at least 30 items. None of the tree and shrub species eaten accounted for more than 4 percent of the food items. Similarly, animal foods, mushrooms, soil, ornamental flowers and vegetative leaf and stem parts were of minor importance. Approximately 83 percent of the above items were not found in each month's diet.

During April and May, supplemental foods accounted for 37 percent of all foods eaten (peanuts 32 percent). Twenty-seven percent of the spring diet consisted of flowers, fruits and buds of elms, black walnuts *(Juglans nigra)* and some oaks. Other noteworthy spring foods were the leaves and stems of grass, tulips and magnolia flowers.

Supplemental foods were also the most frequently eaten items in summer (43.7 percent) with peanuts accounting for 33 percent. Immature oak acorns and buds composed a large portion of the summer diet (16.7 percent). Sawtooth oak *(Quercus acutissima)* and pin oaks were the most frequently eaten park oak species. In late summer, flowers and fruits of Japanese pagoda were second in importance to supplemental food. Boxwood and horsechestnut fruits were eaten more frequently at this time than during the spring or fall. Other summer foods were geranium flowers and maple samaras *(Acer* sp.*)*. An unidentified soil-inhabiting invertebrate and an aphid gall were the only animal foods eaten during the study.

Visitor handouts dominated the squirrels' diet in October. Nearly 75 percent of all foods eaten were of five supplemental foods. Peanuts were the most prevalent supplemental food (50 percent), although this was proportionately less than during the other months. This was due to the availability of supplemental acorns which accounted for 18 percent of the supplemental foods. English walnuts were also heavily utilized by the squirrels. The remaining items in the October diet mainly consisted of buds and leaves of at least ten tree and shrub species.

Of the 30 different tree species in Lafayette Park, nine (30 percent) were not eaten by squirrels. All trees that produced an abundance of food were mature, one exception being a hemlock *(Tsuga canadensis)*. These species were ginkgo, green ash, black gum *(Nyssa sylvatica)*, little leaf linden, yellow-wood *(Cladrastis lutea)*, and American hornbeam *(Carpinus caroliniana)*. Squirrels also did not feed on yews and azaleas.

Squirrels rarely obtained food from park visitors eating lunch in the park, because squirrels were not usually active at midday in warm weather when most picnickers frequented the park. Although the garbage cans usually contained edible food, Lafayette Park squirrels were never observed entering them to retrieve food or nesting material. However, refuse on the ground was used.

Damage Assessment

During the nine months of this study, gray squirrels were wholly or partially responsible for the aesthetic and physical decline of park vegetation. They were more destructive to park trees and shrubs than had been reported in past years.

Many park trees showed visible signs of stress—defoliated crowns and scars from bark chewing. Some trees with extremely sparse canopies developed sucker shoots. Dead branches and leaves were evident in numerous trees.

Most squirrel damage resulted from nest building and feeding activities during the summer. Squirrels were constantly pruning trees in order to construct and maintain the large number of leaf nests in the park. Trees with the most nests usually received the most trimming. American elms, English elms, willow oaks, pin oaks, and white oaks were particularly susceptible to damage. During late April and early May, squirrels ate immature black walnut fruits, so that none matured. Similarly during the summer, squirrels virtually consumed all underdeveloped, button-sized acorns, so that none were available in the fall.

Squirrels also damaged trees by gnawing on bark, sometimes by stripping it and

Table 1. Food items eaten by 349 gray squirrels at Lafayette Park, Washington, D.C. (Figures are percent of occurrence. B=bud, F=flower, FR=fruit, L=leaf).

	Month						
	April	May	June	July	August	October	Total
Number of items eaten	109	101	78	64	98	69	519
Number of feeding squirrels	64	71	52	45	66	51	349
Item							
Peanut	30.3	32.7	33.3	34.4	32.6	50.7	34.9
American elm (B, F, FR, L)	9.2	4.9	1.3	6.2	0.0	1.4	4.0
Japanese pagoda (B, F, FR)	1.8	4.0	1.3	1.6	10.2	5.7	3.8
Pin oak (B, F, FR, L)	3.7	3.0	3.8	3.1	6.1	1.4	3.7
Sawtooth oak (B, F, FR, L)	2.7	3.0	3.8	3.1	5.1	1.4	3.3
Black walnut (B, F, FR)	1.8	5.9	3.8	3.1	1.0	1.4	2.9
Oak acorn	1.8	0.0	0.0	1.6	3.1	13.0	2.9
English walnut	1.8	2.0	1.3	1.6	4.1	5.8	2.7
Willow oak (B, F, FR, L)	5.5	3.0	2.6	1.6	1.0	1.4	2.7
White oak (B, F, FR, L)	1.8	3.0	5.1	1.6	3.1	0.0	2.5
Grass	5.5	0.0	3.8	3.1	2.0	0.0	2.5
Northern red oak (B, F, FR, L)	0.9	4.0	2.6	3.1	0.0	1.4	1.9
Horsechestnut (B, F, FR)	0.0	2.0	3.8	0.0	3.1	5.7	1.9
Magnolia (F, FR)	2.7	1.0	1.3	1.6	1.0	1.4	1.5
Chicken bone	0.9	2.0	0.0	4.7	1.0	1.4	1.5
Unidentified soil invertebrate	0.0	0.0	2.6	3.1	4.1	0.0	1.5
Peach pit	0.0	0.0	1.3	3.1	2.0	0.0	1.2
Geranium flower	0.0	0.0	0.0	0.0	6.1	0.0	1.2
Boxwood (FR)	0.0	1.0	3.8	3.1	0.0	0.0	1.2
Apple	0.0	2.0	1.3	0.0	1.0	5.7	1.2
American beech (B, FR)	0.9	3.0	0.0	0.0	0.0	5.7	1.2
Tulip flower	4.9	0.0	0.0	0.0	0.0	0.0	1.0
Bald cypress (FR)	0.0	1.0	1.3	1.6	1.0	0.0	0.8

Soil	1.8	0.0	1.3	0.0	1.0	0.0	0.8
Colesium maple (B, F, FR, L)	0.9	1.0	0.0	3.1	0.0	0.0	0.8
Sycamore (B, FR)	0.0	0.0	1.3	3.1	0.0	0.0	0.6
Plum pit	0.0	0.0	0.0	0.0	3.1	0.0	0.6
Smooth leaf elm (B, F, FR, L)	0.0	0.0	0.0	0.0	2.0	1.4	0.6
Mushroom	0.9	0.0	1.3	0.0	1.0	0.0	0.6
Paulownia (FR)	0.9	1.0	0.0	0.0	0.0	0.0	0.4
Bread	0.9	0.0	0.0	1.6	0.0	0.0	0.4
English elm (B, F, FR, L)	1.8	0.0	0.0	0.0	0.0	0.0	0.4
Korean ash (FR, L)	0.9	0.0	0.0	1.6	0.0	0.0	0.4
Indian strawberry (F, L)	0.0	0.0	0.0	0.0	1.0	0.0	0.2
Big leaf linden (L)	0.0	0.0	0.0	1.6	0.0	0.0	0.2
Nordman fir (L)	0.0	1.0	0.0	0.0	0.0	0.0	0.2
Aphid gall	0.0	1.0	0.0	0.0	0.0	0.0	0.2
Holly (L)	0.9	0.0	0.0	0.0	0.0	0.0	0.2
Unidentified	14.7	18.8	18.0	7.8	4.1	5.8	12.0

at other times by eating the moist, spongy, and loosely cellular cambium on both the inner bark and exposed wood of stripped trees. Bark damage occurred at all locations on trees, although the most common site was on or near branches where bark was spirally stripped and/or girdled. Squirrels gnawed exposed areas from which branches had fallen or been pruned. Bark damage on tree trunks was usually located immediately adjacent to branches.

Most bark damage occurred during May and July. Heavily damaged species were American elm, English elm, sycamore *(Platanus occidentalis),* American beech *(Fagus grandifolia),* willow oak, saw-tooth oak and pin oak.

During feeding and nest building activities, squirrels dropped twigs and leaves, creating litter that park maintenance personnel had to continually collect.

Damage to tulips and geraniums was less than had been reported in past years. Less than 12 percent of these flowers were damaged by wildlife during the course of this study. Damage to tulips and geraniums occurred to all plant structures, although the most serious was clipping off the inflorescence at the peduncle. Damage to flowers was not exclusively caused by squirrels; and considering the large number of human visitors, pets and wildlife utilizing the park, flower damage was low.

People-Squirrel Interactions

Feeding was one of the most important interactions between park visitors and squirrels. The majority of supplemental foods offered to squirrels were peanuts, English walnuts and acorns. Some visitors fed squirrels directly from their hand, others threw food to the animals. A few people even placed peanuts in cracks and crotches of trees or at the bases of larger trees.

We differentiated between two types of people that fed squirrels, using the analogy of "zoo visitor" and "zoo keeper" to describe them. Most public feeding was fortuitously done by commuters and tourists. They usually fed only squirrels that moved near them and typically watched the squirrels eat the food thrown to them. This type of feeder most resembled a "zoo visitor."

The "zoo keeper" was characterized by at least six dedicated people who routinely visited the park specifically to feed the squirrels. Generally these people fed the squirrels raw peanuts three or more times a week throughout the year. Some even collected acorns and maple samaras from outside the park to bring to the Lafayette Park squirrels. They placed food throughout the park, whether or not squirrels were visible, and rarely watched the squirrels eat. The major difference between the "zoo keeper" and "zoo visitor" probably was in their reasons for feeding the squirrels. "Zoo keepers" fed squirrels because of concern for the animals' well being, whereas "zoo visitors" fed squirrels for entertainment.

Approximately 90 percent of the supplemental food available to the squirrels were attributed to six "zoo keepers." Two of these people fed the squirrels greater quantities and more frequently than the other four. These two put out food at least six days a week in the winter and five days a week during other seasons. During warmer months, they placed a total of approximately eight pounds (3.6 kg.) of raw peanuts in the park each visit and doubled this amount in winter. Over a year, these two individuals distributed nearly 3,000 pounds (1359 kg.) of peanuts for the Lafayette Park squirrels. At approximately 57 cents a pound (July 1980 wholesale cost) they each spent nearly $855 a year to feed the squirrels. Their total expenditure on peanuts was probably greater than this, because they also fed squirrels at their homes and at other parks. In addition, one of the "zoo keepers," because of poor health, paid a person a dollar ($1) an evening to feed the Lafayette Park squirrels for her. Her total financial commitment to feeding the park squirrels was therefore over $1,000 per year.

One other "zoo keeper" fed squirrels peanuts and English walnuts five days a week in only a few sections of the park and across the street in front of the White House. Another "zoo keeper" brought about eight pounds (3.6 kg.) of acorns a week from other parks as long as they were plentiful.

Peanuts distributed in the park for squirrels were generally in surplus and were consumed by other park wildlife. For example, of a sample of 195 peanuts in July and August, squirrels ate 27 percent and buried 34 percent. Pigeons and common grackles ate 21 percent of the peanuts and 14 percent remained untouched after 30 minutes. Leftover peanuts were usually eaten by rats and birds, not squirrels. Thus park "zoo keepers" not only supported squirrels but also species considered pests in urban areas.

People other than "zoo keepers" also fed the squirrels. More than once during the winter months, unknown benefactors put out fresh iceburg lettuce, potatoes, carrots and celery for the park squirrels. Many people even searched in park garbage cans and threw food remnants, such as sandwiches or fruit, on the ground for park wildlife.

In addition to feeding, at least two "zoo keepers" cared for park squirrels in other ways. They daily refilled small plastic water bowls at the base of park trees to ensure that the squirrels would have water to drink. Once one of the women distributed small bundles of hay, the equivalent of one bale, beneath several park trees for squirrels to use as nest material.

Together these "zoo keepers" often acted as a lobbying group, voicing their opinions to the park maintenance and management staff on issues they thought relevant to the park squirrels. For example, they were opposed to the recent reintroduced Peregrine falcons *(Falco peregrinus)* into downtown Washington, D.C., as they adamantly believed the falcons would prey upon young squirrels. They also wanted more nest boxes put in the park. They felt the squirrels would not survive the approaching winter without additional boxes.

Aside from the few "zoo keepers," it was uncommon for people to visit the park specifically to see the squirrels. Most people using the park were picnickers, commuters, or tourists. Most of their interactions with squirrels were incidental and of short duration. Nevertheless, many of these people photographed the squirrels, watched their antics and in general, enjoyed their presence. Out-of-town tourists, especially foreigners, sought out the squirrels with enthusiasm and even asked questions about them. It was our impression that when squirrels were active and visible in the park, they were the third most popular sight after the White House and park statues.

Discussion

Gray squirrel densities at Lafayette Park are the highest reported in the literature. The highest previous density was five to six squirrels per acre (0.4 ha) in

2 ten-acre (4.0 ha) suburban Baltimore, Maryland woodlots (Flyger 1959). The high density at Lafayette Park is likely to have resulted from both the tremendous quantity of continually available supplemental food and the large number of artificial nest boxes (26). Direct relationships have been shown between the availability of food and squirrel population densities (Nixon et al. 1975). Barkalow and Soots (1965) and Burger (1969) found increased numbers of gray squirrels after artificial dens had been added to forested areas.

Despite diverse types of human activity in and around Lafayette Park (joggers, police sirens, demonstrations, etc.) there was no apparent difference in the squirrels' activity patterns from those reported in other areas. Baaken (1959), Thompson (1977b) and others described spring and summer activity patterns similar to those at the park, where most activities occurred during early morning and late afternoon. The October Lafayette Park squirrel activity pattern also resembled the general fall pattern observed by Thompson (1977b), where peaks of activity were increasingly displaced toward midday.

Evidence that downtown squirrels move to and from Lafayette Park conflicts with reports indicating that squirrels in scattered city parks tend to be isolated populations where unusually colored gray squirrels, such as white, albino and black, may be due to genetic drift (Baldwin 1969, Flyger 1970). Movement into the park probably occurs primarily because of the year-round availability of supplemental foods. Squirrels often crossed bordering streets to bury peanuts outside the park.

Characteristics of leaf nests in Lafayette Park differed from those of wild squirrels. Park leaf nests tended to be lower and in smaller trees than those found by Fitzwater and Frank (1944) in a Connecticut second growth hardwood forest. Uhlig (1956) recorded that most leaf nests were constructed in the summer and late October in West Virginia. The number of leaf nests in Lafayette Park was greatest in July. The most notable distinction was that park leaf nests were generally more abundant than reported from other areas (see for example, Robinson and Cowan 1954, Uhlig 1956).

No previous studies of gray squirrel food habits revealed a population as dependent on supplemental foods as the Lafayette Park squirrels. For example, Robinson and Cowan (1954) reported that artificial foods such as peanuts and biscuits only accounted for approximately 8 percent of the total diet of gray squirrels in a Vancouver, B.C., Canada park woodland. The Lafayette Park squirrels did eat available nonsupplemental foods that were used by squirrels in other locations—elm buds, flowers and samaras (Nichols 1927, 1958), floral organs of oaks (Nixon et al. 1968) and horsechestnut nuts (Nichols 1958, Thompson and Thompson 1980). However, most fungi and animal foods which are generally important foods in other gray squirrel populations (for example, Nixon et al. 1968, Stienecker 1977), were observed to comprise only a relatively small quantity in the diet of the Lafayette Park squirrels.

Gray squirrel damage to vegetation is not unique to Lafayette Park. Flyger (1970, 1974) reported that urban gray squirrels are destructive to gardens and ornamental trees and shrubs. Red, gray and fox squirrels have debarked sugar maples, oaks and conifers throughout their North American ranges (Pike 1934, Pearce 1947, Brenneman 1954, Englehard and Bragonier 1960, Gooden 1961). The most severe gray squirrel damage to tree bark has probably occurred in England

(Davidson and Adams 1973a, 1973b).

Encounters similar to the people-squirrel interactions observed in Lafayette Park have been noted in other settings and with other wildlife species (More 1979). Wildlife feeding is mostly done around people's homes rather than at public parks. Nevertheless public feeding like at Lafayette Park has been high in some other urban parks (Huessman and Burrell 1974, Hardin and VanDruff 1978). These authors as well as Gill and Bonnett (1973) and Ordish and Binder (1967) noted a small percentage of park visitors who daily feed wildlife, like the Lafayette Park "zoo keepers." As at Lafayette Park, squirrels in other urban areas were well-liked. Gray squirrels were the second most popular wild mammal in the city of Waterloo, Canada (Dagg 1974) and the most popular in metropolitan areas of New York (Brown et al. 1979).

Implications and Recommendations

Conditions as described above would be expected to continue if no action was taken to deal with squirrel impacts on park vegetation. However, based upon the activities of park squirrels and the public in Lafayette Park, there are many considerations that can influence management efforts to maintain a healthy park.

Reducing the number of park squirrels is one strategy that may help minimize damage to vegetation. However, removal of park squirrels will have no lasting effect on lowering the high squirrel density. Continual squirrel movement in and out of the park from adjacent areas will probably replace those removed. The presence of large quantities of supplemental foods ensures immigration of new inhabitants. For removal alone to be effective, it would have to be a continuing effort carried out at least twice a year. A more efficient and long lasting method would be simultaneous removal of squirrels and reduction of supplemental foods.

Removal of only part of the resident population at the park may increase, not decrease, tree and shrub damage. Taylor (1969) showed that the interplay of resident and immigrant squirrels creates social tension that apparently is expressed as damage to trees, shrubs and flowers.

Chemosterilants would problably not be effective in reducing the squirrel population within a short time period. Squirrels readily enter the park so a reserve of squirrels would always be available. Park squirrels possibly live longer than wild squirrels and, assuming no increased mortality or egress, it is doubtful that the population would decline rapidly.

Prohibition of public feeding in the park would lower the carrying capacity for squirrels, rats and pigeons but would also probably cause an increase in squirrel damage to park vegetation. Sudden elimination of peanuts might cause squirrels to compensate for absence of this food by feeding on trees, shrubs and flowers. Park visitors who feed squirrels for enjoyment would be denied an important component of their park experience. This policy would be very difficult to enforce. The public has been feeding Lafayette Park squirrels for at least 50 years (Horace Wester, pers. comm.).

Providing alternative foods has been fairly successful in preventing some wildlife damage to crops, orchards and conifer seedlings (Sullivan 1979). However, since public feeding at Lafayette Park is partially responsible for the existing high squirrel density, additional supplemental food distributed by park personnel or the public would further raise the park carrying capacity for squirrels. Since peanuts are now in excess, more food would also support more rats and pigeons.

The keen interest and concern for the squirrels by some of the public may at times interfere with other interests in the park. Programs which are perceived as harmful to the squirrels, such as relocation and prohibition of public feeding, would be intensely opposed, if not legally challenged. Because of past policies, bad experiences, and the park's continual emphasis on the squirrels' negative qualities, some "zoo keepers" distrust the park management staff. The park's close proximity to the White House and high visibility to the public further amplifies any friction between the public and park managers. Strategies to reduce squirrel-park conflicts will be continually scrutinized by the public and may prove difficult to implement.

At this point in our study, the following management approaches seem to hold the most promise for reducing future damage to park vegetation, improving relationships between park management and the public and enhancing a healthy squirrel population in the park.

1. Since damage to park vegetation rather than the presence of squirrels is the major concern of park management, the greatest effort should be directed at minimizing damage. This can partially be accomplished by not planting certain flowers, such as geraniums, known to be damaged by squirrels. Flowers can be sprayed with repellents to further discourage their use by squirrels. Preliminary results at Lafayette Park suggest that a mixture of hot chili sauce, water and a sticking agent is sometimes effective in reducing flower damage. Metal guards can be placed around the trunks of each of the isolated trees to prevent squirrel movements into the branches where most bark and twig damage occurs. Guards should also be fastened to all new trees planted in the park. The surface of the metal guards can be painted to resemble natural tree bark to reduce their visibility to the public. Possibly bark damage could be reduced if beef bones were hung in concealed tree locations providing the park squirrels with a source of calcium and phosphorous, as well as an object to gnaw on.

2. Efforts should be initiated to reduce surplus peanuts in the park. This can be accomplished through formal and informal meetings with those individuals who daily feed squirrels large quantities of peanuts. It should be emphasized that the objective is not cessation of public feeding, but reduction in the number of peanuts available to rats and pigeons. Visitors should be informed that peanuts should be distributed only when squirrels are visible and at least one hour before sunset, to increase the probability that they will be eaten by squirrels and not by other animals. Waste would be reduced if squirrels were fed individually rather than by placing food at the base of trees. "Zoo keepers" should be made aware of seasonal differences in peanut use by squirrels. Rather than placing peanuts on the ground where they are easily accessible to pigeons and rats, numerous elevated feeding stations could be erected in the park.

3. If vegetation damage continues and management decides to reduce squirrel numbers, arrangements might be made with the Humane Society to euthanize the removed animals. This would be more humane than releasing them into areas already saturated with resident squirrels, where they would have little chance for survival. However, regardless of how "humane" this may be, squirrel benefactors and others may severely criticize the park for killing squirrels. If squirrels are

removed, there should be a concurrent reduction of supplemental foods.

4. Long-range management of the park should be aimed at reducing unnatural conditions that presently exist. Park personnel should begin planting trees that are valuable to squirrels as well as to park aesthetics. Many hickories, chestnuts, pecans, and crabapples grow well in urban areas and their mast could eventually replace peanuts as the squirrels' most important food. Dead tree limbs that contain cavities should not routinely be cut or pruned unless dangerous to the public. If this strategy is practiced, then a smaller number of nest boxes would be necessary in the park.

5. Because squirrels are of great interest and concern to both the public and the park management, the development of an interpretive program at the park would be of value. Brochures and/or bulletin boards could present information on the biology and ecology of the park squirrels and how this compares to squirrels in more natural areas. The public could be informed of the best times of day in each season in which to observe, photograph and feed the squirrels. Proper and safe ways of feeding squirrels and the role of public feeding in the park could be discussed. Park managers could voice their concerns about past, present and future squirrel problems, as well as promote their efforts to improve park conditions for squirrels (e.g. planting mast trees). Information could be in two or three major foreign languages, for the convenience of the many foreign visitors to the park. Press releases to the media, tour guides, local environmental groups and others could publicize the squirrels as one of the most interesting and important features of Lafayette Park. Such efforts would help demonstrate to the public that the park management is concerned with squirrels not only as pests, but as a valuable park resource.

Acknowledgments

Particular thanks to R. Hammerschlag for his unabated support and valuable suggestions. S. Singer, A. Johnsen, R. Hammerschlag and B. Anderson provided comments on the manuscript. Appreciation is extended to B. Ruback, L. Kelly, C. O'Hara and E. Drotos for administrative assistance.

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Wildlife-related Activities and Attitudes of Pennsylvanians

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Wildlife management can be defined as " . . . the science and art of changing the characteristics and interactions of habitats, wild animal populations, and men in order to achieve specific human goals by means of the wildlife resource" (Giles 1971). For most of the profession's history, the emphasis has been on management of habitats and game populations; the specific human goal has been a huntable or fishable resource.

In recent years consideration of needs of urban wildlife, recognition of non-consumptive uses of wildlife, and concern for endangered species are evidence of a widening scope of wildlife management. As wildlife agencies attempt to meet all these new demands, they come into conflict with a variety of special interest groups who have strong particular management goals. Wildlife managers are forcefully reminded of the "people" element of the definition of wildlife management.

Kenneth Norris (1978), in an article on marine mammals for the book *Wildlife in America,* explained why the human aspect was often neglected in wildlife management. "In large part, it seems to me, we talk about managing animals and their environments because it is the easy thing to do. Dealing with our fellow humans and our institutions, on the other hand, can stir up immediate responses, often not very peaceful."

The increasing importance of people and their opinions to managers is illustrated in part by the rise in the number of surveys conducted by wildlife professionals. Hendee and Potter (1971) reported that between 1960 and 1970, only six articles on people–wildlife topics appeared in the *Journal of Wildlife Management* (out of 698 total articles). Two years later Hendee and Schoenfeld (1973) were editors of papers from a special session of the North American Wildlife and Natural Resources Conference which centered on human dimensions in wildlife management. Recent survey literature addressed many topics of interest to wildlife managers, e.g. attitudes toward hunting, nongame wildlife, and animals in general (Applegate 1979, Brown and Dawson 1978, Dagg 1970, Dagg 1973, Kellert 1976, Kellert 1979, More 1979, Shaw and Gilbert 1974, Shaw et al. 1978).

How attitudes are formed or changed can depend on many factors—one of interest is place of residence on an urban-rural gradient. Although some researchers might argue that mass media communications have eliminated many of the differences in attitudes between populations from urban and rural areas, studies have demonstrated urban-rural differences. Shaw et al. (1978) showed that while 46 percent of urban residents approved of hunting, 68 percent of rural dwellers approved. Schole et al. (1973) found that although 52 percent of their sample of Colorado hunters had spent their childhood in rural areas, 45 percent of those hunters were residing in population centers of 50,000 or more when they answered

A report on Project 2456 of The Pennsylvania Agricultural Experiment Station. Research was supported by McIntire-Stennis Act funds and the U. S. Forest Service Consortium for Environmental Forestry Studies. This paper, although included in these transactions, was not presented at the 46th Conference.

the survey. Kellert (1978) demonstrated that childhood residence was a stronger predictor than current residence for all wildlife-related activities where residence was significant.

Pennsylvania has an interesting history which includes urban and rural components. Large cities, e.g. Philadelphia and Pittsburgh, are truly part of the eastern megalopolis which dominates portions of the state. Pennsylvania still has the largest rural population of any state, and also has the largest number of hunters of any state. Thus Pennsylvania seemed suitable for a study of wildlife-related activities on an urban-rural gradient.

Objectives of the Study

The objectives of this study were to:

1. determine the frequency of participation of Pennsylvania adults in selected wildlife-related activities;
2. evaluate the importance of the urban-rural gradient to these activities;
3. assess some general attitudes toward nature and the issue of funding sources for nongame management.

Methods

A statewide telephone survey based on random digit dialing was used. Random digit dialing involves computerized-generation of random digit telephone numbers and was originally developed as a way to obtain both listed and unlisted telephone numbers (Dillman 1978). The Institute for Human Development at The Pennsylvania State University, which conducts statewide polls on a variety of topics, generated the random-digit dialing list for this study. Interviews were conducted by three students from the School of Forest Resources.

Surveys were conducted from May to July of 1979. Most calls were made between 6 and 9 PM on weekdays; additional calls were made between 1 and 4 PM on weekdays, and on weekends. A total of 1,888 different numbers were called. Twenty-five percent ($N=472$) of the calls were to working numbers where an interview was attempted. Fifty-eight percent ($N=273$) completed the interview; 40 percent ($N=191$) refused the interview, and 2 percent ($N=8$) started but did not complete the interview. Of the 273 completed interviews, 261 were usable.

Frequency of Participation in Selected Activities

Table 1 shows the frequency of participation in selected activities. For the species observation question, respondents were read a list of seven birds and seven mammals and asked if they had observed any of the animals on their property. All animals listed were considered to be generally recognizable. The exception was the avocet, which was used as a check on question format, e.g., to see if respondents were tending to agree with the list of animals. Respondents were also asked if they had observed salamanders, frogs, toads, or snakes on their property.

Seventy five percent of the respondents reported putting out food for birds and mammals. This feed included everything from bread and table scraps to commercial

Table 1. Frequency of participation in selected wildlife-related activities by respondents in the Pennsylvania sample.

Activity	% reporting participation
Observation of selected species	
Robin	98
Rabbit	85
Cardinal	80
Gray squirrel	75
Starling	73
Bat	46
Pheasant	41
Rat	36
Raccoon	35
Skunk	32
Mockingbird	30
White-tailed deer	29
Red-tailed hawk	9
Avocet	<1
Snakes	38
Toads	28
Frogs	25
Salamanders	18
Fed birds and mammals	75
Had bird feeders	34
Bird-watched at some time	30
Hunted at some time	25
Had bird baths or nest boxes on property	25
Put out traps or poisons to control animals	22
Had membership in nature or wildlife-related group	15
Planted vegetation for wildlife	7

feed. Only 34 percent actually had bird feeders on their property. Of the respondents with bird feeders, 51 percent fed only in winter, while 49 percent fed in additional seasons. The average poundage of seeds fed was: 36 pounds (16 kg) for those who fed only in winter; 75 pounds (34 kg) for those who fed winter plus other seasons; 57 pounds (26 kg) for all respondents. Nineteen percent of the respondents could not give any estimate of how much they fed and approximately five percent said it depended on the severity of the winter.

While 30 percent of the sample reported bird watching at some time, only 8 percent said they watched birds at least once each week.

Twenty five percent of the sample reported hunting at some time in their life; 14 percent had hunted for more than five years.

Other activities are also listed in Table 1.

Significancy of Urban-rural Gradient

All activities were cross-tabulated with childhood and/or current residence. Four residence categories were defined: (1) a center city or high density suburb; (2) a low density suburb; (3) a small town or village; and (4) a rural or farm area. A chi-square test ($P = 0.05$) was used to determine if there was any difference in the frequency of these activities relative to the residence gradient.

Observation of birds or mammals on the respondent's property was tested against current residence. Current residence was only significant for observation of two bird species: red-tailed hawk and pheasant. Respondent's current residence was also significant for observation of six of the seven mammal species: raccoon, rat, rabbit, white-tailed deer, skunk, and bat. Observation of the reptiles and amphibians was significantly related to current residence; totals were too sparse for a test by individual species.

Bird feeding, other feeding of birds and mammals, having bird baths or bird houses, and planting for wildlife were not significantly related to childhood residence. However, when the same variables were cross tabulated with current residence, bird feeding was significant while the others were not. Participation in wildlife-related groups and trapping or poisoning on respondent's property were not significantly related to current residence. Hunting was significantly related to both childhood and current residence; birdwatching was not significantly related to either residence.

Attitudes Toward Nature and Non-Game Funding

Two sets of questions addressed attitudes; respondents were asked whether they strongly agreed, agreed, were neutral, disagreed or strongly disagreed with the statements read. Table 2 shows responses; since only two questions had more than 10 percent in either of the strong categories, responses were summarized as agree or disagree.

The only two statements which drew strong agreement or disagreement were numbers 1 and 4 under General nature. Statement 1 had 14 percent strongly agree, while statement 4 had 19 percent strongly disagree.

Refusal Rate

Four different introductions were used to attempt to reduce the refusal rate so a representative sample could be obtained. A chi-square test ($P = 0.05$) showed no significant difference in refusal rate among the four introductions. There was also no significant difference in refusals among different interviewers.

Some authors have reported occurrence of higher refusal rate for a variety of reasons which include importance of group conducting the research, or saliency of topic to the respondent (Baumgartner and Heberlein 1977, Dillman 1978). Kellert (1979) encountered a 22 percent refusal rate in a nationwide personal interview survey and mentioned that this may have resulted ". . . from the relative unimportance of the subject to some segments of the public, and from increasing difficulties recently noted in obtaining access to people's homes for personal interviews." These results show an increasing resistance to interviews, and indicate that surveys should be carefully considered to maximize response.

Characteristics of Respondents

Characteristics of respondents in the survey were compared with characteristics

Table 2. Percentage of respondents who agree, are neutral, or disagree with the listed statement on nature and non-game funding.

Statement	Percent agree	Percent neutral	Percent disagree
General nature			
1. Forests are important primarily for seeing beauty and wildlife.	80	3	17
2. In the beginning, man learns from nature, but once man learns nature submits to him.	63	11	26
3. Man has the specific know-how to improve on nature.	70	6	24
4. There is nothing special about trees, they just take longer to grow than most crops.	10	4	86
5. The law of the forest is a law unto itself; "nature" tells man what is in the public interest not vice versa.	63	16	21
Non-game funding			
1. More research efforts should be put into research on non-game species, in other words, those species which cannot be hunted but which could be beneficial to urban and suburban residents.	81	12	7
2. I would be willing to buy a nongame stamp or other device to raise money for non-game species research.	58	20	22
3. I think general tax monies should be used to help manage non-game wildlife.	69	14	17
4. I feel that most of the wildlife research efforts should continue to be directed toward game species, in other words those species which could be hunted, trapped, or fished.	38	14	48

for the general population of Pennsylvania (U. S. Bureau of the Census 1970, Pennsylvania Department of Commerce 1980). In general, survey respondents had higher education levels and higher average income. For example, while 8.8 percent of the population had completed four years or more of college, 20 percent of the survey respondents had attained this educational level. While 3.9 percent of the general census population had family income greater than $25,000, 14 percent of the survey respondents were in this category. Several researchers have indicated that interest in conservation and wildlife is related to education or income status (Devall 1970, Fazio and Belli 1977, Harry et al. 1969, Kellert 1979). It seems that respondents in this survey had a higher than average interest in wildlife and were more likely to agree to an interview.

Discussion

Many people were able to report observation of animals on their property. More than 99 percent of the respondents reported not seeing an avocet, or that they did not know what one was; so it seemed that most respondents were not simply agreeing with the list.

Frequencies of wildlife-related activities were similar to findings of other studies. DeGraaf and Payne (1975) reported 20 percent of the households in the United States feeding an average of 60 pounds (27 kg) of seed. Brown and Dawson (1978) in a study of Albany metropolitan residents reported that: 34 percent had bird feeders, 50 percent fed wildlife, 11 percent had birdhouses, 16 percent provided water, and 10 percent made plantings. Horvath (1974) in a study in the Southeast found that 17.2 percent fed birds, 15.9 percent had birdhouses, and 14.2 had birdbaths. Kellert (1980), in a nationwide survey, found that 67.7 percent of respondents fed birds; 21.3 percent of the sample fed for more than 151 days (or two winters). This feeding was not restricted to commercial seed. Approximately 11 percent of respondents in Kellert's study belonged to conservation organizations; 24.9 percent reported hunting at some time in their life although only 14.5 percent had hunted in the past two years. Twenty-five percent reported watching birds. All studies indicate that there is considerable interest in animals.

Findings on the urban-rural gradient are more difficult to interpret. Observation of the red-tailed hawk and pheasant, which one would expect to occur in rural habitats, was related to residence. The lesser observability of mammals probably accounted for six of the seven mammals species being significantly related to residence since some of these species are found in a variety of habitats. The gray squirrel, which is diurnal and highly observable was the only mammal whose observation was not related to area. Reptiles and amphibians also would be expected to be seen more frequently in certain habitat types. The significance of bird feeding by current residence was probably due to a small number of people feeding in the center city and high density suburbs. Hunting has been shown to be related to childhood residence, and the same relationship was found in this study. The lack of significance of the urban-rural gradient to the other variables illustrates two points: (1) hunting is a special case and (2) that a variety of factors can influence other activities.

The attitude responses point to the importance of forests for their aesthetic values as well as utilitarian uses. The fact that statements 1 and 4 under general nature were the only ones which elicited strong feelings shows the special feelings people have for trees in their environment. Statements 2 and 3 under general nature illustrate respondents' confidence in our ability to manage resources; yet statement 5 illustrates an underlying belief in what nature can offer to us. Although the majority of people in this study did feel non-game species should be investigated (81 percent in statement 1 on non-game funding); 42 percent were hesitant to commit their money to buying a non-game stamp. This could have been natural caution at being "trapped" into buying one, or a desire to hear more specifics about a program. More of the respondents (69 percent) thought general tax monies could be used for non-game. There was still strong support for game species (38 percent in statement 4 of non-game funding), illustrating the interest in game species in Pennsylvania.

Summary

As wildlife managers are called upon to manage limited resources for the maximum number of people, the opinions of these people will become increasingly important. These survey results suggest that there is a high degree of interest in wildlife, especially around respondent's homes, and that wildlife professionals could move ahead more rapidly in non-game management than they have. There is also increasing evidence of difficulty in getting people to answer surveys.

Acknowledgements

We would like to thank Dr. Ben W. Twight, Assoc. Professor of Forest Resources, The Pennsylvania State University, for the five-question scale on general nature attitudes in Table 2.

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The Value of the Wild-bird Products Industry

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The scope of wildlife management has greatly enlarged in recent years. Increasing suburbanization is one of the factors which has expanded the focus of wildlife managers. Wildlife biologists have examined the interests of suburbanites and have found an emphasis on nonconsumptive uses of wildlife (Brown and Dawson 1978, More 1979). Therefore such varied states as California, Colorado, Missouri, New Jersey, and Pennsylvania have developed programs with an emphasis on nonconsumptive uses and experimented with several techniques of funding.

Non-game programs cannot be funded solely from consumptive use (hunting and fishing) revenues, although some states have used portions of their "game" funds to initiate non-game programs and many "game" commissions have been renamed "wildlife" commissions to denote broader interests. One potential source of funds for non-game is general appropriations; wildlife is a public resource and can therefore qualify to be managed for maximum human benefits with general funds. Another source of funding is a special-use tax such as the manufacturers' excise tax on sporting arms and ammunition which funds the Federal Aid in Wildlife Restoration Act of 1937 (Pittman-Robertson Act) or the comparable tax on fishing equipment (Dingell-Johnson Act). Some of the items which have been suggested for taxation for non-game program funding are off-road vehicles, backpacking equipment, photographic supplies, and wild-bird feeding supplies and equipment (Wildlife Management Institute 1975). Propositions for an excise tax on many of these items have encountered organized opposition by various outdoor groups because the items have uses not always directly related to wildlife. A tax on wild-bird feeding supplies and equipment has legislative appeal since this equipment, like that for hunting and fishing, is used mainly for a special purpose. People who feed birds would benefit from non-game management and research programs and, by the nature of their activity, already are showing a commitment to non-game species. The original version of Senate Bill 2181, "The Fish and Wildlife Conservation Act of 1980," (U.S. Senate, 96th Congress) contained an 11 percent excise tax on mixed wild-bird seed, houses, feeders, and baths in addition to a general appropriation for the first four years of the program.

The purpose of this study was to determine a preliminary wholesale value of the wild-bird products industry to learn whether the industry constituted an adequate financial base for an excise tax to fund a non-game program, and to give this information to the Congress. Although the bill passed, the tax was deleted. The Act requires further study on possible sources for funding including an excise tax. This study provides a basis for evaluating the potential yield from a tax on the wild-bird products industry.

The study was conducted in two phases: (1) a literature review, and (2) surveys of manufacturers (informal telephone and formalized mail surveys). The literature

A report on Project 2456 of the Pennsylvania Agricultural Experiment Station. Research was supported by the Wildlife Management Institute. This paper, although included in these transactions, was not presented at the 46th Conference.

review included published and unpublished sources on two topics—the value of the bird feeding industry and estimates of numbers of people feeding birds. A list of manufacturers for the questionnaire survey was compiled from the Thomas Grocery Register (1979), from informal surveys of local bird equipment distributors, and from suggestions by manufacturers. Preliminary telephone surveys showed that the manufacturers often could not answer some of the questions related to their total sales because such information was not readily available. A mail survey seemed more appropriate to encourage complete and accurate answers from respondents who could obtain required information without the time restrictions which occur in a telephone survey.

Literature Review

Economic Values

Cross (1973) in a study for the Maine Fish and Game Department estimated that approximately 30 percent of the households in Maine fed birds; and an average of 124½ pounds (56.5 kg) of seed was used by each of those households in 1972. Cross cautioned that the bird feeding statistics were probably high because a large number of people in the mail survey had an above-average interest in birds.

A mail survey by the Massachusetts Audubon Society (1974) provided a base for estimating that the average household which bought feed purchased 60 pounds (27.3 kg) in a year. A telephone survey of randomly selected households was used to determine that 33 percent of the households fed birds. With this information they estimated that 35.3 million pounds (16 million kg) of seed would be sold in a year in Massachusetts alone (for a retail value of $8 million).

In 1975 a report from the Wildlife Management Institute included wild bird food as one source for an excise tax to fund non-game programs. The Institute's report stated that the 1972 manufacturers' shipments of wild bird food had an estimated worth of $19.9 million. No data on houses, feeders, or baths were presented. The Institute provided us with supplementary data to their 1975 report. The wholesale estimate of $19.9 million was based on manufacturer's information for the feed industry alone. That information was provided from records assembled at the University of Missouri.

The article most frequently cited as a source for estimates for the bird feeding industry was written by DeGraaf and Payne (1975). Based on the literature and market survey data, they estimated that approximately 20 percent of U.S. households fed an average of 60 pounds (27.3 kg) of seed each year. Using this information they estimated that total annual retail sales of feed in 1974 were $170 million ($85 million wholesale). Based on information from one supplier, they estimated sales of $15 million ($7.5 million wholesale) for bird houses and feeders. Also they estimated that in 1972, with fewer households and with bird seed at half of the 1974 prices, retail sales were $80 million ($40 million wholesale). The combination of 1972 and 1974 gave a basis for estimating trends.

Ferriss (1980), while reviewing the topic of winter bird feeding, mentioned estimates of up to $340 million in sales for the industry. He presented no information on how he obtained those figures.

Two manufacturers provided market surveys, but requested confidentiality of the source. One of these market surveys (based on a nationwide sample by a survey research firm) quoted an average of 20 percent of the households feeding approximately 58 pounds (26.4 kg) of seed to wild birds in 1969. Assuming the same percentage of households fed birds in 1972, 773 million pounds of seed would have been sold with a retail value of about $70 million.

Regional Variation in Bird Feeding

More (1979) reviewed several studies which show regional variation in numbers of people who feed birds. He mentioned the Massachusetts Audubon Society study (1974) which estimated that 33 percent of the households in Massachusetts bought bird seed. Researchers studying the metropolitan area of Albany in New York found that 34 percent of the residents had bird feeders (Brown and Dawson 1978). Only 17.2 percent of the residents in the Southeast United States had bird feeders (Horvath 1974). Aney and Cowan (1975) reported that 46 percent of adults in Oregon fed birds (not necessarily bird seed). More (1979) concluded that a national average of 20-25 percent of households feeding birds was not unreasonable. More also indicated that the demand seemed to be greatest in the Pacific Northwest and the North Central regions and lowest in the Southeast (while noting that data from all regions are not available).

In a random telephone survey of 261 Pennsylvania residents by Snyder[1], 75 percent of the respondents reported feeding something to birds; however only 34 percent of the households had bird feeders. Among those with bird feeders, the average amount fed was 57 pounds (25.8 kg). These data might overestimate the number of people having bird feeders in Pennsylvania, since the survey had a 41 percent refusal rate and the sample had higher education and income levels than average. However, even if all those who did not answer the survey did not feed birds, a minimum of 20 percent of the households had bird feeders. Assuming the sample was more representative of feeders than non-feeders, the estimate of pounds fed was not as biased.

Kellert[2], in a nationwide study, found that 67.7 percent of the people fed birds in the past two years. This feeding, however, was not restricted to commercial bird feed. Although Kellert did not gather information about pounds of seed fed, he did determine the number of days respondents put out feed for birds. Only 21.3 percent fed more than 151 days (or at least two winters).

Additionally, Kellert provided data on days feeding by region. One portion of these data, illustrating the percent of people feeding for 151 days or more within each region, is shown in Table 1.

Manufacturers Survey

Questionnaire Results from a Mail Survey of Manufacturers

Sixty-one manufacturers of products for wild birds were telephoned. Interviewers explained the purpose of the study and requested permission to mail a ques-

[1]Unpublished data from Arlene P. Snyder, Research Assistant, School of Forest Resources, The Pennsylvania State University, University Park, Pennsylvania.

[2]Unpublished data from Dr. Stephen R. Kellert, School of Forestry and Environmental Studies, Yale University, New Haven, Connecticut.

Table 1. Percent of persons feeding birds for 151 days or more in the past two years, by region of the country where the respondents lived.

Region of the country	Percent feeding for 151 days or more
Northeast	26
North Central	23
Rocky Mountain	22
South	18
Pacific	17
Alaska	17

tionnaire to the company. The questionnaires were mailed with a prepaid return envelope and a cover letter which included telephone numbers where the researchers could be contacted with questions. Sixty-two percent (38 of 61) of the manufacturers completed the survey. Following a telephone reminder, 19 of the manufacturers indicated that they would return the questionnaire, but then did not send it. Four manufacturers refused to answer the questionnaire. Questionnaires were returned during March and April, 1980.

The questionnaire included questions on items manufactured or distributed, regional distribution of sales, estimates of the total value of the industry's products, seed production areas, and comments on an excise tax. Many manufacturers were not able to give a breakdown of their sales either by state or by region. Some manufacturers felt that this information was confidential; others sold to distributors and could not determine readily where their products were marketed. Seventeen companies were able to provide regional marketing data. Fifteen manufacturers had sales in the Northeast region; and 10 of these manufacturers had 50 percent or more of their business concentrated there. Although 13 manufacturers had some business in the North Central region, only two had more than half of their sales there. Ten manufacturers did some business in the Midwest, only one manufacturer had more than half of his business in that region. Ten manufacturers had sales in the Southeast; all sales were less than 20 percent of the manufacturer's total business. Four manufacturers mentioned business in the Southwest; and four mentioned business in the Pacific states. Alaska and Hawaii were mentioned by only one manufacturer.

Most of the companies supplied a wholesale dollar value for their individual company's sales of wild-bird products. These data will not be presented separately, since manufacturers asked that this be confidential information. These data were used to calculate an estimate for the entire industry. The estimate was obtained by multiplying the total wholesale value of products of all manufacturers by the approximate market percentage the responding companies constituted (the approximate market percentage was obtained in the informal telephone conversations with manufacturers). Estimates of $52 to $80 million wholesale value for the wild-bird seed business and $7 million wholesale for the house/feeder/bath business were calculated.

In a further effort to get an estimate of the wholesale value of the industry, manufacturers were asked if a value of $45 million for feed and $15-20 million for houses, feeders, and baths (best estimates based on preliminary data) was low, about right, or high. Four felt the estimates were low, 10 felt the values were almost right, and six felt the estimates were high. Thirteen manufacturers were unsure; five did not answer the question.

Manufacturers were also asked whether the industry was increasing, decreasing, or stable. Seventeen manufacturers felt it was increasing; 13 felt it was decreasing; and four felt it was stable (four manufacturers did not answer the question). Many manufacturers provided additional comments on this topic. Manufacturers who felt the industry was increasing cited factors such as promotion and advertising, greater interest in birds and wildlife preservation, local availability of bird seed in stores and nurseries, and an increase in the middle-age segment which finds this hobby attractive. Reasons presented for a declining industry included inflation, mild weather, changes in lifestyles not compatible with the hobby (apartment living, working housewives, etc.), and higher prices for an item which is not a necessity.

Manufacturers' Estimates of Product Sales Value of the Industry

Based on the questionnaire results and some information from the informal telephone conversations, minimum and maximum wholesale values for the wild-bird products industry were obtained (Table 2). The informal telephone survey revealed the importance of questionnaire wording; many manufacturers reported only mix-seed sales unless specifically asked to include straight seeds. This was made clear for the mail questionnaire survey. These estimates do not include the "cottage industry," e.g., local stores or groups selling seed, or Cub Scouts making bird houses and the like. It is extremely difficult to assess these sources, and to date we have not been able to do so. The estimates for the total industry (all products) varied from $29 to $81 million but the average estimate given by the majority of manufacturers was about $65 million.

Discussion

History of the Business

To obtain our best estimate of the value of the industry, the literature and manufacturers' surveys were compared. Since the most recent literature estimates

Table 2. Manufacturers' estimates for the minimum and maximum wholesale value of the wild bird products industry, by product.

Produce		Minimum	Maximum
Wild bird seed[a]	Pounds	165,000,000	730,000,000
	Dollars	$28,000,000	$61,000,000
Wild bird feeders	Dollars	$500,000	$19,000,000
Wild bird houses	Dollars	$250,000	$750,000
Wild bird baths	Dollars	$250,000	$250,000
Total sales		$29,000,000	$81,000,000

[a]Mix and sunflower, not including thistle seed.

were for the wholesale values in 1974, a basis for the comparison was needed. Through telephone conversations with manufacturers, an informal history of the business was outlined. This outline provided a basis for comparisons.

The history of the wild-bird product industry is a surprisingly brief one—concerned mainly with the past decade. From 1970 to 1973, the mass media prompted public concern about the effects of man's actions on the environment. Pesticide poisoning was one critical issue, and helped to focus public attention on the plight of wildlife. Part of this concern manifested itself as care for wild birds, through feeding and provision of nest sites. The year 1973 was the best year for the wild bird products industry. In 1974, sales began to decline and remained down for several years. Manufacturers felt that increasing inflation caused a tightening of budgets and a subsequent decline in purchases of non-essential products such as bird seed or feeders. Since the bird feeding business is seasonal, mild winters can affect sales. By the winter of 1979-80 sales were still about 10 percent below the 1973 peak figures, even at current prices, according to one manufacturer. Unfortunately many of us interested in market value of wild bird products assumed the trend shown from 1972 to 1974 continued to 1978 and therefore that the industry had doubled. At present there are several estimates in the popular literature which appear to be much too high—probably by a factor of two.

Comparison of Literature and Manufacturers' Survey

The best estimate from the literature is that approximately 20 percent of the households feed an average of 60 pounds (27.3 kg) of seed each year. Therefore in 1978, (based on the most recent number for households from the U. S. census), 15 million households fed 900 million pounds (408.2 million kg) of seed to birds. At an average price of \$0.10 per pound, this would mean that \$90 million wholesale was spent for feed. Assuming feeder, house, and bath sales to be the same as cited by DeGraaf and Payne, a total industry value of approximately \$98 million would be postulated. This assumes no increase in bird feeding; rather, that the industry has nearly come back to its 1974 size.

The manufacturers' average estimate was between \$60 and \$65 million for the entire wild-bird products industry. The lowest total value for the industry was \$29 million and the highest was \$81 million.

The literature estimate is much higher than the average industry estimate (\$60—\$65 million) but within range of the highest manufacturer's estimate of \$81 million. Part of the discrepancy between the literature and the highest manufacturer's estimate can be explained by a time factor. The literature value was based on the 1978 sales; manufacturers were estimating their 1979 sales. The winter of 1979 was a mild one, and sales were down from the previous year.

Using literature estimates for pounds fed, 900 million pounds (408.2 million kg) would have been purchased in 1978. This is higher than the average industry estimate of 500 million pounds (226.8 million kg) but within range for the highest manufacturer's estimate of 730 million pounds (331.1 million kg) when considering the time factor.

Based on these figures, an 11 percent excise tax would have produced between approximately \$7 and \$10 million in revenue (since such a tax would be levied at the wholesale level). This amount alone would have financed only a modest nationwide non-game program (especially with funding of 9:1,federal:state). Additional supplemental income would have been needed.

Consumer Characteristics

Results of the literature review demonstrated regional differences in bird feeding—with the Northeast and North Central regions having the highest percentages of people feeding birds. Manufacturers also confirmed this; a high portion of businesses giving regional data had major sales in these regions. The sales in these areas are undoubtably tied to snow cover and the image of the birds not being able to fend for themselves. Thus, there will be some changes in the potential market from year to year depending on the weather.

Manufacturers expressed concern that a tax would adversely affect older citizens, whom they felt were a major portion of their market. They based this assumption on one market survey where 75 percent of the respondents were over 45. This survey was distributed to individuals who responded to a mail order for bird feeding products. The survey cautioned that results were for the specific group studied and were not generalizable to all persons feeding birds.

Snyder[3] found only 47 percent of the people who had bird feeders were over 45; and 26 percent were 56 or older. Because of the higher level of education and income in this Pennsylvania sample, one might hypothesize that older people on fixed incomes might have been under-represented.

However Kellert[4] also found that among people who fed for more than 150 days, only 53.2 percent were over 45 and 34.3 percent were over 55. His sample was representative for the United States.

Fixed income is not a problem for all individuals over 45, it is mainly a concern for those over 65. The percentage in that group is not a majority of people feeding birds.

Areas for Research and Further Clarification

One major finding of this study is the lack of readily available information on the wild-bird products industry. Until recently, there was no formal organization of wild-bird products manufacturers; therefore, no single listing of wholesalers was available. Many of the manufacturers themselves were unsure of the size of the total market. The Department of Commerce does not keep records on the ultimate use of seeds which are important components of some mixes; thus, documented poundage statistics were not available.

One problem with comparing estimates of people feeding birds is that these questions often are not asked uniformly. While some researchers ask about having bird feeders, others ask about buying seed or simply feeding birds. Therefore replies vary from individuals with many feeders and seed purchases to that for individuals feeding occasional table scraps on the ground. Also rural farm people feed very differently than urbanites. It is extremely difficult to compare these types of information. Probably the only way to obtain uniform information would be

[3]Unpublished data from Arlene P. Snyder, Research Assistant, School of Forest Resources, The Pennsylvania State University, University Park, Pennsylvania.

[4]Unpublished data from Dr. Stephen R. Kellert, School of Forestry and Environmental Studies, Yale University, New Haven, Connecticut.

through a specific question asked in a nationwide survey.

The most pressing issue is a mechanism for funding non-game management programs. To date, good starts have been made in several states using a variety of approaches. Missouri, for example, has a program funded by a one-eighth of one percent sales tax. Colorado, using a tax check-off box on income tax forms (which enabled individuals to designate part of their refunds for the non-game fund), raised $350,000 in the first year and $500,000 in the second year of this program. These programs are very successful. Several states, including Iowa, New Hampshire, Michigan, New Jersey, California, and recently Pennsylvania have sold conservation stamps to raise money. A variety of items, such as T-shirts and decals, have also been sold to raise funds. The contributions from the sale of these items have been valuable. Often they do not form a stable base for a sustained statewide program. The idea of an excise tax such as the Federal Aid in Wildlife or Fish Restoration Acts seems appropriate for a sustained funding base. However, taxes on outdoor products have met opposition from the special interest groups involved.

Kellert (1979), for example, using data from his national survey for the U.S. Fish and Wildlife Service, found that while 57 percent of the general public supported a tax on backpacking and camping equipment to help pay for the cost of wildlife conservation, only 49 percent of the backpackers did. While 71 percent of the general public supported a tax on off-road vehicles (ORVs), only 58 percent of frequent ORV users did. Among birdwatchers, 51 percent supported a tax on birdwatching equipment and supplies; 54 percent of the general public approved such an option. This illustrates a gap between the measures which are acceptable to the general public and those which can be approved by the special interest groups concerned. This is the key area for research because a stable economic base must be found for the non-game program.

One final point concerns the question of administration of a non-game program. Although several states have and are making good beginnings in non-game research and management, a federal program would be the stimulus for a nationwide effort. Many non-game species are migratory and thus must be handled on a federal level. A comprehensive national program also could coordinate and set standards for research on species. The need for coordination was clearly illustrated by bird feeding statistics already reviewed. Questions on this topic were asked in such diverse ways that results were difficult to compare. A comprehensive program could also provide for larger research efforts—with several states pooling information or sharing programs. A federal program, especially one which provided matching funds like the Federal Aid in Wildlife or Fish Restoration programs, would stimulate additional states to get involved in non-game conservation and planning—states which otherwise might not have sufficient funds to get involved in this area.

Summary Evaluation

As a result of this investigation it is our opinion that: (1) The best estimate for the wholesale value of the wild bird feeding industry in 1980 is at least $90 million wholesale ($180 million retail). (2) Many of the estimates in the popular literature which report double the above retail figure are based on projections of earlier trends which did not continue. (3) The bird feeding industry is a recent one, mainly developing within the past decade. Although it experienced a period of rapid growth in the early 1970s, it has since fluctuated around the peak 1973 level rather than increasing. It is a business which experiences seasonal and yearly fluctuations depending on weather and other factors. There is also a cottage industry which cannot be easily determined. (4) Approximately 20–25 percent of households feed birds an average of 60 pounds (27.3 kg) of seed per household. There is important regional variation; the Northeast and North Central are centers for the activity. (5) The majority of bird feeders are middle-aged or younger—not over 65 as the manufacturers indicated. (6) Information on bird feeding is difficult to obtain. The Department of Commerce does not have specific breakdowns on many seeds used for bird feed. Some manufacturers did not know the size of the total; some reported only mixed seeds. Additional confusion is found in studies of who feeds birds; information can include anything from feeding of table scraps to feeding of commercial mixes. (7) Our best estimate is that a tax in 1980 might have generated $10 million dollars. This amount alone would not have supported a large nationwide non-game management and research program; but a federal program would help coordinate and stimulate non-game management and research. (8) The manufacturers in the wild-bird product industry are strongly opposed to a tax on their products, but support the non-game program.

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Integrating Wildlife and Forest Management

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Introduction

The business of conservation, the planned management of resources to ensure current and future productivity, is done on the ground as well as in the legislatures and courts. There is a considerable distance between laws (National Forest Management Act of 1976) that call for an ecosystem approach to resource management and getting that job done. Field application of ecosystem approaches to land management is still in its infancy. We have concepts, philosophies, and perspectives, not tried and true procedures.

We discuss four aspects of the integration of wildlife habitat needs with timber management: (1) philosophies and laws, (2) historical approaches, (3) an example at the field level, and (4) thoughts about the realities of ecosystem management. This approach is a process, not a rigid set of constraints.

Philosophies and Laws

The multiple-use philosophy of National Forest management is at the heart of resource integration concerns (Wengert et al. 1979). This philosophy was refined and made binding by such legislation as the Multiple Use Sustained Yield Act of 1960, and the Renewable Natural Resources Planning Act of 1974 (RPA) as amended by the National Forest Management Act of 1976 (NFMA). It was also extended to the non-reserved public domain by the Federal Land Policy and Management Act of 1976 (FLPMA). Because the resource land base is relatively fixed and demands for goods and services from that land are increasing, integration of management is essential.

Multiple-use has applied for over 9 decades, while perceptions about appropriate balances among resources, society's expectations for wildlife, and coordination methods have changed markedly. The National Environmental Policy Act of 1969 (NEPA) heralded a major shift in expectations about public resources. Followed by such legislation as the Endangered Species Act of 1973, RPA, NFMA, FLPMA, and the recent Fish and Wildlife Conservation Act of 1980, the Federal conservation legislation of the 1970s fixed in law a revolution in conservation perceptions (Thomas 1981). Nelson (1975) claimed we are entering an era of coordinated intensive management of forest resources in which interdisciplinary planning is the key.

When Aldo Leopold (1949:207) spoke of a "land ethic" and defined conservation as " . . . a state of harmony between men and land" the terms ecosystem and ecological diversity were novel concepts. Now, our conservation laws recognize the ecosystem as a functional unit through which renewable resources are produced, and ecological diversity as a critical attribute in sustaining productivity. Further, Leopold's (1949:204) admonition that "a land ethic changes the role of *Homo sapiens* from conqueror of the land-community to plain member and citizen of it" is woven into the fabric of the new laws.

The Forest Service is implementing these laws through regulations for land and resource management planning. The regulations require treatment of public issues and the management of all resources through interdisciplinary planning on each National Forest. Coordination with other Federal and state agencies and private organizations is part of the process. The process incorporates planning concepts for fish and wildlife: (1) use of management indicator species, (2) maintenance of viable populations of all native and desirable non-native vertebrates, and (3) maintenance of plant and animal species and community diversity.

Historically, emphasis has been focused on game, predators, and threatened or endangered species. The management indicator species concept expands that focus to include species which indicate the welfare of other species with similar habitat requirements or which indicate the conditions of special habitats such as snags and riparian areas. The concept still allows forest management to emphasize certain species over others for economic, recreational, aesthetic, and ecological reasons, but the emphasis is no longer confined to game and rare species. The "featured species" concept of Holbrook (1974) has been given a broader ecological perspective.

The maintenance of viable (self-perpetuating) populations is intended to prevent the future jeopardy of species whose needs for special habitat requirements could cause population declines through anticipated habitat changes. It also promotes the recovery of endangered species so that they can be removed from the lists. The viable population requirement is difficult and controversial to deal with empirically as populations of many species, such as grizzly bears (*Ursus horribilis*) and spotted owls (*Strix occidentalis*), require large land areas for long-term viability, and their habitats also have high commodity values.

The rationale for maintaining diversity is to ensure that the biological and physical variety of natural resource ecosystems is maintained; population viability is directly related to species diversity over the long-term. Diversity has received much attention (e.g., Patrick's 1978 collection of papers), and has been applied to forest management by Siderits and Radtke (1977). Diversity as an applied concept deals with the richness of species and communities, their relative abundances, and their distribution.

This era of National Forest management, guided by these new laws, philosophies, and expectations, needs practicable procedures for field level management. Regulations and concepts which are still vague to many field practitioners have to be made a part of their everyday jobs.

Integration Approaches and Principles

Many principles useful in integrating wildlife habitat needs with timber management have been developed and applied. Aldo Leopold's (1933) early text identified many basic habitat concepts. Edminster (1935) noted that extensive monocultures of densely stocked conifers were detrimental to game, and he recommended plantations be no larger than 600 feet (183 m) in diameter and be interspersed with hardwoods, shrubs, and herbaceous openings. Miller (1935) reported that leaving a forest in its natural state did not necessarily result in good game habitat, and suggested manipulating food and cover by using tree harvest, thinning, and other silvicultural practices to provide game and timber—a call for integrated management. McAtee (1936) cited forestry practices detrimental to wildlife, especially those that reduced diversity, and he recommended maintaining openings and brushfields. Pattern, edge, diversity, patch size, habitat management, and resource integration had all been recognized for their importance to wildlife by 1936.

The scant literature on integrated habitat management during the 1940s and 1950s probably reflects the emphasis on wildlife population management during that period. Giles (1962) developed a comprehensive approach to integrated planning using the watershed as a planning unit and applied a prescription for habitat pattern for one to a few selected species. He emphasized the need for a species-specific, integrated resource plan to provide wildlife products where wanted, usable, manageable, and where they will not cause unacceptable problems for other resources. Shaw (1967) suggested a blend of selection and clear-cutting be scheduled over time and space to maintain mast and fruit in juxtaposition to herbaceous openings and browse stands—a dynamic approach to habitat conservation. Both Giles (1962) and Shaw (1967) illustrated a hypothetical managed area. Starker Leopold (1966) discussed the relationships of big-game species to successional stages, a precursor to the development of species-habitat relationships (Patton 1978, Thomas 1979). The literature of the 1960s introduced area plans, featured species, species-habitat relationships, and the scheduling of practices to attain multiple objectives.

Marcström (1970), writing about Swedish forests, summarized the then state-of-the-art by recommending a pattern of successional stages, intensive forestry only on the most suitable sites, wildlife habitat priority on marginal timber sites, forage producing stands in juxtaposition to cover producing conifers, control of clear-cut block size, and thus the provision of a diverse ecosystem. Holbrook (1974) described how the featured species concept fosters integrated wildlife and timber management by using rotation length, stand size, stand distribution, site preparation, intermediate cutting, and prescribed fire as joint management practices.

Roach (1974) demonstrated that both wildlife habitats and timber can be regulated in a cost effective manner for a sustained yield on relatively small land areas of 500 to 5,000 acres (200 to 2,000 ha). Nelson (1975) presented a thorough approach to integrated resource planning on such areas which highlighted uneven-aged forest streamside zones, conservation of seeps, snags, and mast trees, and sustained timber production largely through regeneration cutting.

Most of these integration approaches emphasized the use of practices in a pattern that leads to forest diversity as an outcome of managing for specific resources—timber and featured wildlife. Siderits and Radtke (1977) used diversity itself as a goal for wildlife. They created a pattern of stand conditions through a blend of rotation length strategies for both conifers and hardwoods. Multi-resource prescriptions were written for each stand. There was no distinction between management for game and non-game species.

Patton (1978) and Thomas (1979) expanded the concept of big-game habitat relationships to all species and emphasized the integration of featured species and diversity approaches to habitat management. Thomas (1979) also developed principles for managing "special" habitats such as snags, cliffs, downed logs, and riparian areas, and presented silvicultural options to achieve goals for wildlife (Hall and Thomas 1979). Others developed species-habitat relationships data bases (Patton 1978, 1979, Verner and Boss 1980, Mason et al. 1980), and management principles for featured species (Lyon 1975, Lyon and Jensen 1980, Thomas et al. 1976) to provide the information needed for increased coordination. The literature of the 1970s emphasized management for both game and non-game wildlife, ecosystem diversity, sustained yield regulation of both timber and wildlife habitat products, and the application of wildlife habitat relationships in addition to using previously developed concepts.

In reviewing forestry and wildlife Starker Leopold (1978) stressed the need to better understand the relationships between wildlife and forest successional stages. The maintenance of the full spectrum of wildlife requires a mosaic of all forest successional stages. Leopold noted that a lack of early and late successional stages, and the regeneration of forests in large, dense monocultures are the most detrimental aspects of intensive forest management for wildlife. But, forests need not be so managed. Vegetation management done in keeping with the multiple-use philosophy and new legal requirements will result in forest conditions characterized by ecological diversity.

The approaches to integrated management reviewed here give rise to some principles for integrating wildlife habitat management into multiple-resource forest management: (1) biologically based, tractable *Management Areas,* (2) specific wildlife and other *Resource Goals* for each area, (3) *Habitat Criteria* for wildlife on the area, (4) long-term *Scheduling of Management Activities* (e.g., roading, stand regeneration, thinning, forage seeding, etc.) on the area, (5) *Stand-by-stand Management Prescriptions,* and (6) *Monitoring and Revision* (Table 1).

An Application of Integration Principles

The Management Area

A 3,584 acre (1450 ha) area on the west slope of the Sierra Nevada mountains was used to test this approach to integration. The area, 3,500 to 4,200 feet (1070

Table 1. Some principles for integrating wildlife habitat management into multiple-resource forest management.

1. MANAGEMENT AREAS: Areas should be based on resource capabilities, home range size of featured wildlife, watershed boundaries, vegetation conditions, and other criteria such as transportation and administrative lines. All resource managers should use designated areas in common.

2. RESOURCE GOALS: Goals and objectives for all resources should be described for each area. Wildlife goals should include species and community diversity and the featured species on the area. Timber goals include volume to harvest, acres to regenerate, acres to thin, treatment costs, etc. Selection of featured species should be based on:

   a. Socio-economic demands of resource users
      i. Forest land management plans
      ii. New information on public issues, management concerns, and resource use and development opportunities
      iii. Comprehensive statewide wildlife management plans

   b. Habitat capability and wildlife needs
      i. Information on area resources
      ii. Information on species-habitat relationships

   c. Management practicability
      i. Public and other agency support and cooperation
      ii. Logistics
      iii. Costs and benefits

   d. Compatibility with other resource values and practices

3. HABITAT CRITERIA: Quality standards for featured species habitat, road design, logging systems, fuels, new stands, diversity, etc., guide planning and project work. The habitat criteria should be expressed in terms that other resource specialists can understand, and in terms of management practices:

   a. Habitat criteria
      i. Stand area sizes
      ii. Stand shapes
      iii. Stand species composition and density structure
      iv. Distribution of stands (juxtaposition)
      v. Relative amounts of each successional stage
      vi. Conditions of designated special habitats (e.g., snags)

   b. Silvicultural and timber management practices
      i. Rotation length (cutting cycle)
      ii. Logging and transportation systems
      iii. Site preparation
      iv. Regeneration (species composition and density of trees and shrubs)
      v. Stand management practices (release, thinning, fertilization, prescribed burning, etc.)
      vi. Costs (direct costs and opportunity costs)

4. ACTIVITY SCHEDULING: Stands within the area should be scheduled for treatment:

   a. Prioritize stands needing immediate treatment or protection
   b. Give most attention to activities in the current decade
   c. Work toward regulation of the areas's resource products
   d. Schedule over space and time with future options in mind

5. STAND PRESCRIPTIONS: Management of each stand should be based on site potential, vegetative conditions currently in the stand, and the role of the stand in meeting overall area goals. Each stand prescription should integrate to the extent possible the needs for timber and wildlife habitat resources.

6. MONITORING AND REVISION: On a 5 to 10 year period make necessary changes:

   a. Monitor results of activities
   b. Assess changes in resource goals
   c. Incorporate new knowledge into habitat criteria
   d. Revise activity schedules
   e. Develop new stand prescriptions

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to 1280 m) in elevation, has annual precipitation in excess of 50 inches (127 cm), most falling as rain between October and May. The forest type is predominantly mixed-conifer ranging from 10-year-old plantations to 90-year-old stands. Soils are productive. Well stocked stands of 5,000 to 8,000 cubic feet of wood per acre (350 to 560 cubic m per ha) are growing 125 to 145 cubic feet per acre (9 to 10 cubic m per ha) per year. Some stands are 40 to 80 percent hardwoods. The area was heavily logged and burned during the gold mining era of 1860 to 1880. Fire or logging results in rapid invasion by shrubs, usually *Ceanothus* spp. and *Arctostaphylos* spp.

The area is a winter range for black-tailed deer *(Odocoileus hemionus columbianus)*, and year-long habitat for band-tailed pigeons *(Columba fasciata)*, pileated woodpeckers *(Dryocopus pileatus)*, western gray squirrels *(Sciurus griseus)*, and many other species. Several small streams support rainbow trout *(Salmo gairdneri)*. Public uses include fishing, hunting, fuel wood gathering, and nature observation. National Forest boundaries and a major river delimit the area.

Resource Goals

Timber goals from the existing National Forest timber management plan are: harvest about 11 million board feet (62 thousand cubic m) and regenerate about 350 acres (140 ha) to commercial conifers per decade. There are no wildlife goals other than general coordination. We used the criteria in principle 2 (Table 1) to develop such goals. Deer, band-tailed pigeon, pileated woodpecker, gray squirrel, and rainbow trout are the featured species. They also serve as management indicator species as required by an NFMA Forest plan. Deer represent early to mid-successional stage wildlife, pileated woodpeckers represent snag-dependent and late successional stage wildlife, the pigeon and squirrel represent mast and conifer seed dependent species, and the trout represents stream quality. The wildlife goal is to maintain or enhance the habitats for these species by providing a pattern of habitats that will, over time, produce a diverse flora and fauna with sustained production of both timber and game. Diversity results from management for these species.

Habitat Criteria

Habitat criteria were developed from wildlife habitat relationships (Verner and Boss 1980), deer habitat management principles (Salwasser in prep.) and timber/wildlife coordination principles being developed by the USDA Forest Service Pacific Southwest Region.

Vegetation is categorized so that both timber and wildlife specialists can use the categories (Table 2). Stages 1 and 2, brushfields and plantations, are considered suitable habitat for early successional wildlife; they are treated as deer forage habitat in this analysis. Stages 3 and 4 are suitable as deer cover in the D canopy class. Stage 4 with a D canopy is also suitable for late successional wildlife. Stages 3 and 4 with an O canopy are understocked for timber production. Optimum mast production occurs only in stage 4 stands containing hardwoods.

To enhance habitat for successional wildlife, regenerated stands should be from 10 to 40 acres (4 to 16 ha) in size, have irregular shapes with undulating edges no more than 600 feet (183 m) apart at their widest point, and be stocked with a mix of native tree species. Shrubs and herbs competing with young trees should be reduced to an average 30 percent cover in both the shrub and herbaceous layers. This maintains travel routes and forage accessibility for deer and allows young conifers to grow on schedule. Regeneration should be scheduled so that adjacent stands have at least 80 percent of their common boundary with at least a two decade age difference. From 20 to 30 percent of the compartment should be in the deer forage classes, stages 1 and 2, to sustain winter forage needs during each decade; their distribution should be dynamic so as to keep young vigorous plants available as a by-product from timber management.

To sustain habitat values for late successional wildlife at least 20 percent of the area should be in stage 4 conifer and hardwood stands with a D canopy cover; the

Table 2. Categorization of vegetation for use by wildlife and timber specialists.

Cover types:

"M" Mixed conifer
"H" Hardwoods

Developmental stages:

1) Grass/forb/seedling tree or shrub (up to 1″ dbh*)
2) Shrub/sapling tree (1″ to 6″ dbh)
3) Pole/small tree (6″ to 24″ dbh)
4) Medium/large tree (greater than 24″ dbh)

Canopy cover of dominant plants:

"O" open; less than 40 percent cover
"D" dense; greater than 40 percent cover

*dbh means "diameter at breast height"; about 4½ ft. (1.5 m) from ground.

larger tree sizes of stage 3 stands may also suffice. A multi-layered, mixed-species tree canopy is desired in these stands, and snags and downed logs should be retained to the extent that they are not fire or safety hazards. Where such stands are adjacent to streams or meadows, or in a sensitive visual resource area (observable from well traveled roads), they should be managed with small group selection harvest to maintain a mature forest condition with minimum disturbance. Designated streamside zones managed in this manner protect the riparian and aquatic ecosystems, thus sustaining the trout habitat. Within these zones restocking harvested sites should be through natural means, or be designed to replace the original forest mix. Mast-dependent wildlife will be sustained on stage 4 hardwood stands, which should constitute at least 20 percent of the total area in hardwood stands.

Activity Scheduling

To provide the habitats required by the featured species over time we partitioned the area into zones: (1) stands on soils or slopes that preclude vegetation manipulation (marginal sites), (2) stands with hardwoods as the dominant trees (to be managed to maintain hardwood production), (3) stands within 200 yards (183 m) of the major streams and the highway that bisects the area (to be managed by combinations of small group selection and shelterwood to maintain a continuous cover of mature forest), and (4) conifer stands capable and suitable for commercial timber production and related successional wildlife habitat (to be managed to optimize timber and featured species values). This partitioning, shown in Figure 1, placed 151 acres (61 ha) (4 percent of the area) in marginal sites due to physical limitations, 548 acres (222 ha) (15 percent of the area) under a hardwood rotation, 535 acres (217 ha) (15 percent of the area) in mature forest/streamside/roadside zone, and the remaining 2,350 acres (951 ha) (66 percent of the area) under a conifer and wildlife habitat rotation. Within the latter area two priorities guided stand scheduling for regeneration: (1) begin immediate regeneration of poorly stocked stands (the "P" stands in Figure 1), and (2) begin some regeneration adjacent to the mature forest zone and roadsides to avoid having to concentrate later decade regeneration in those areas.

Using timber goals and wildlife habitat criteria we selected stands for regeneration and intermediate cutting in the first decade, designed the pattern and shapes of the cuts, and estimated the resulting timber and wildlife habitat yields. In order to ensure that the rate and pattern of regeneration would not seriously affect future options, and provide a continuous flow of timber and wildlife habitat, the same procedure was used for four subsequent decades. At the end of each decade we "grew" the regenerated vegetation using yield tables (Dunning and Reinecke 1933, Oliver and Powers 1978) in order to project habitat conditions and timber production.

Stand Prescriptions

In practice, a stand management prescription would be prepared for each stand scheduled to receive treatment. The prescriptions detail such things as harvest method, site preparation, tree stocking, release of trees from competition, wildlife forage seedings, retention of snags, logs, and slash piles, and thinning of trees.

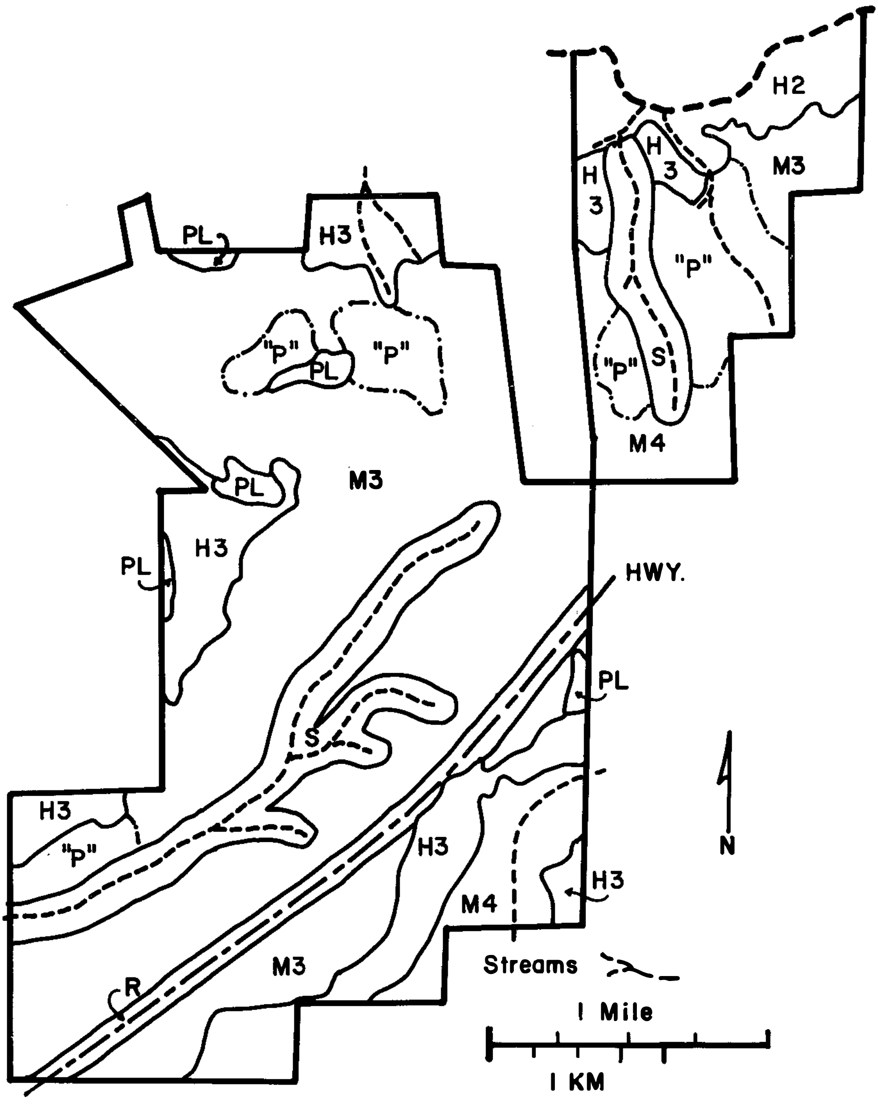

Figure 1. Initial conditions and partitioning of the area. PL = plantations. S = streamside zone. R = roadside zone. H2 and H3 denote hardwood stands of size classes 2 and 3. M3 and M4 denote mixed-conifer stands of size classes 3 and 4. "P" stands are poorly stocked mixed-conifer of size classes 3 or 4. Streamside zone stands are nearly all mixed-conifer size class 4.

Opportunities to use revenues collected from timber sales would be identified and prescribed. We have not included that level of detail in this example. Nor have we dealt with monitoring and revision.

Results and Discussion

Timber and wildlife goals were met through at least five decades (Table 3 and Figure 2). Less than half of the compartment would receive manipulation during the period with these results: (1) harvest of over 11 million board feet (62 thousand cubic m) of timber per decade, (2) regeneration of about 350 acres (142 ha) to commercial tree species and successional wildlife habitat per decade, (3) conservation of mature forest conditions on over 20 percent of the compartment, and (4) perpetuation of mast producing hardwood stands and early successional hardwoods on 15 percent of the compartment. At the end of five decades there would still be 600 acres (243 ha) of mature conifers in stands slated for regeneration. And, by that time, the stands regenerated during the first two decades would contain over 20 million board feet (112 thousand cubic m) of timber, enough to meet the timber goal by harvesting only from these stands. Timber goals would change in response to improved production, but there is flexibility to accommodate changing goals.

During initial decades the area is deficient in deer forage habitat, stages 1 and 2 (Figure 2). Not until the close of the third decade, when the area in stages 1 and 2 reaches the desired 30 percent figure, is deer forage habitat sustained. Hardwood stands augment the deer forage habitat. No regeneration was scheduled in the hardwood stands as they would be in the prime mast producing age throughout the period. However, some treatments would be needed in these stands to ensure future production of browse and mast.

As shown in Figure 3, the net result is a diverse pattern—a mosaic of cover types and successional stages, covering the needs of both timber management and the featured species. To the extent that the featured species represent the habitat needs of other wildlife, this approach can be used to manage for wildlife diversity. The mosaic can be sustained, barring catastrophes such as fire. After five decades about 30 percent of the conifer rotation zone is in early successional stages and

Table 3. Summary of acres regenerated and volume harvested from management zones within the area during each decade.

Management zone	Decade	Acres regenerated	Million board feet harvested
Marginal (151 acres)	all	*	*
Hardwood rotation (548 acres)	all	*	*
Mature forest/streamside/roadside zone (535 acres)	all	*	3
Conifer rotation (2,350 acres)	1	324	11.30
	2	349	11.05
	3	345	11.59
	4	348	11.08
	5	318	11.29
5 decade total		1,684	71.31

*Some timber harvest and regeneration would occur in these areas, but amounts were not estimated for this example.

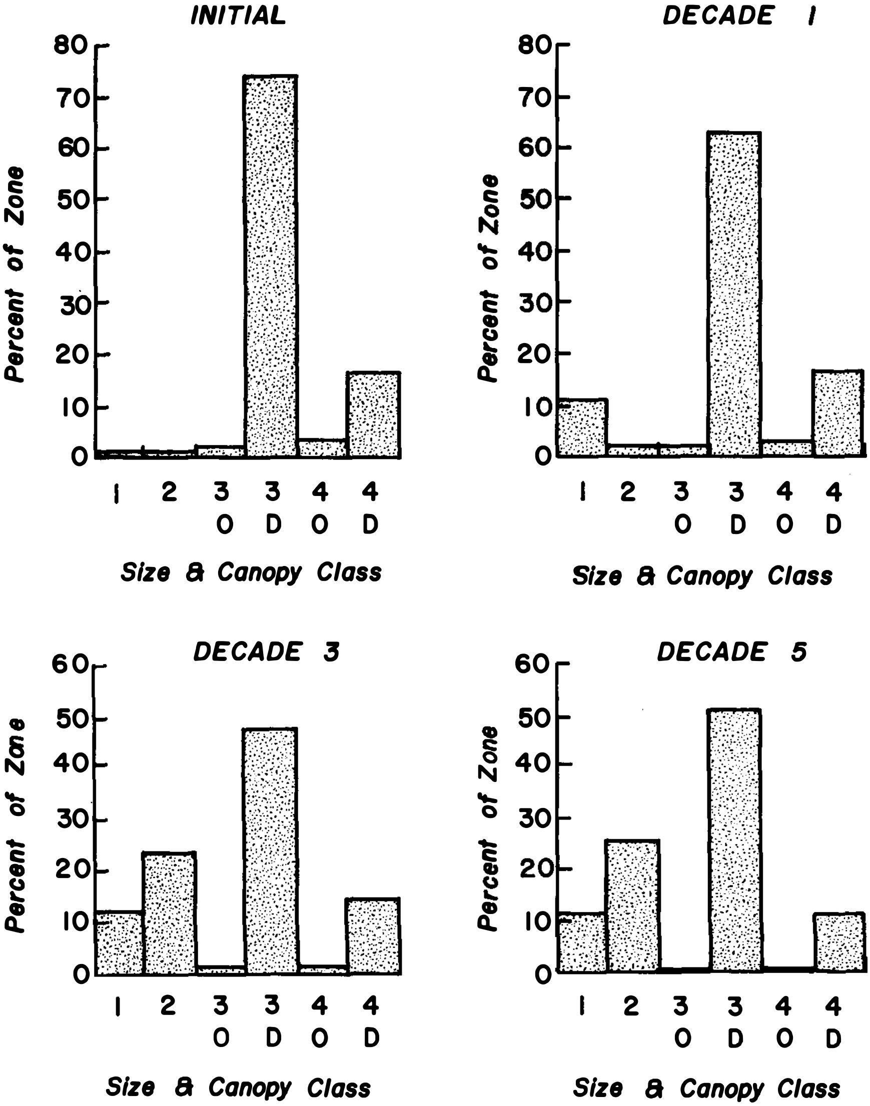

Figure 2. Profile of vegetative conditions in the conifer rotation management zone. Bars represent the percent of area in the zone covered by stands of specified size and canopy cover classes at the end of the indicated decade. The 674 acres (273 ha) of "marginal" brush and hardwood stands and the 535 acres (217 ha) of mature forest/streamside/roadside stands remaining after 5 decades are not included in these profiles.

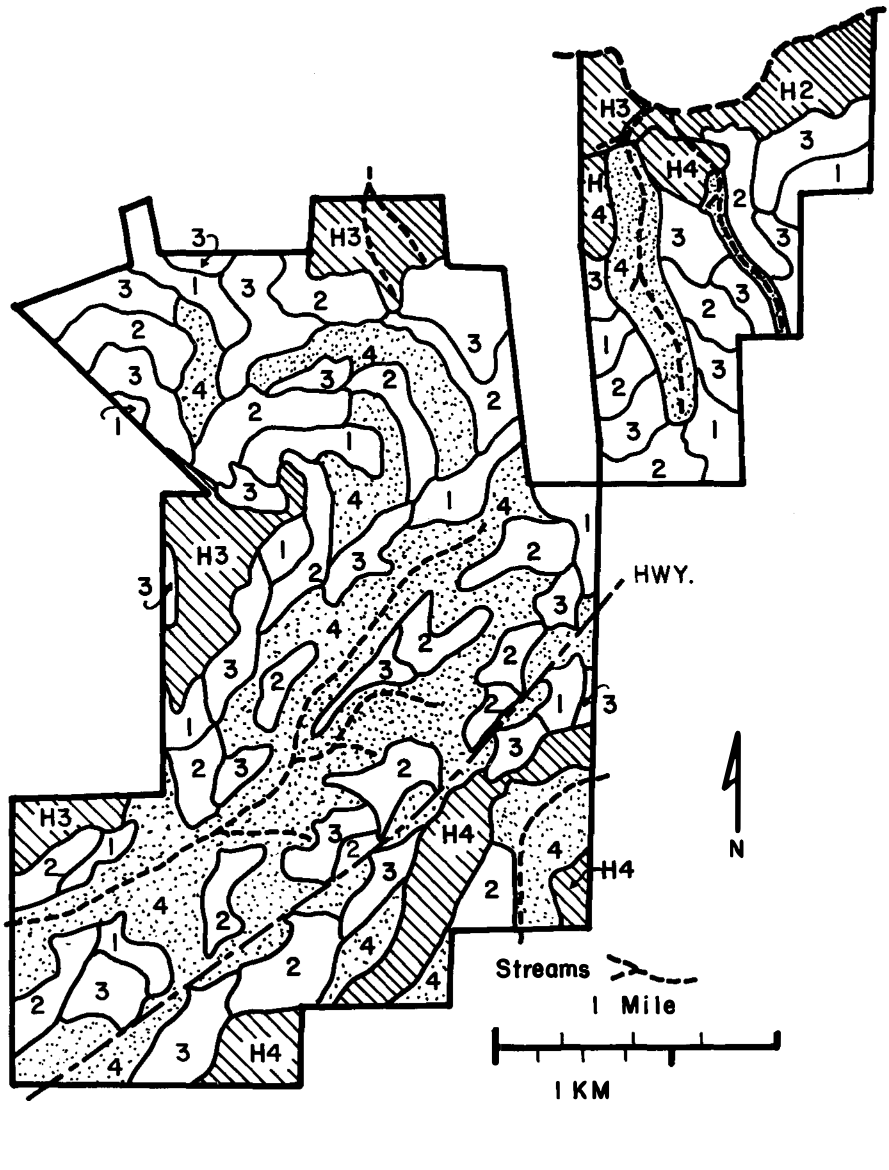

Figure 3. Projected stand conditions at the end of 5 decades of management. Hardwood stands have been "grown" according to site potentials. They are denoted by cross-hatching. Unregenerated mixed-conifer stands are denoted by stippling. They are assumed to have grown to size class 4 by the end of the period. Regenerated conifer stands are indicated by the projected size class of dominant trees at the start of decade 6. See Table 2 for descriptions of size classes of trees.

about 15 to 20 percent is in later and mature successional stages (size class 4 and larger trees in class 3). Using a longer rotation for conifers results in a higher proportion of mature forest; a shorter rotation leads to more early successional stages. It is not possible to have more of all conditions. Thus, management decisions deal with the proportions desired. This example strikes a middle ground in maintaining habitat for a broad range of animals. Other areas with different starting points of vegetation conditions or with different resource goals would lead to different outcomes. Yet, this approach to integration can be applied regardless of the starting conditions.

The rationale for projecting harvest and vegetation change for 5 decades is to show the long-term consequences of current projects and to see if multiple-resource goals are realistic. In no way is such a projection implied to be a plan that must be rigorously followed for 50 years. Too much changes during that time, including goals and policies.

Sustained production of the featured species requires vegetation manipulation. Further, that manipulation can be achieved through a blend of timber management practices that also meet timber goals. In this example timber goals can be met, and probably adjusted upward, without suffering an unacceptable loss in mature forest wildlife habitat or hardwood habitat. Such insights are possible only when specific resource goals are stated and more than just the consequences of activities in individual stands or only in the immediate decade are examined.

Plans constantly change in response to shifting resource values and policies, and to changing land conditions, thus necessitating periodic monitoring and revision of goals, criteria, schedules, and prescriptions. This approach to integrated management is an analysis tool useful for developing plans and projects. It is a means for testing and implementing goals assigned to specific management areas by a more general land use plan, e.g., a National Forest Land and Resource Management Plan. Its usefulness is measureable in terms of higher levels of resource production and the extent to which possible resource conflicts are identified and resolved before projects are initiated.

Summary and Conclusions

Recent shifts in how society values natural resources have led to an increased emphasis on multiple-resource management with an ecosystem perspective. This calls for integration of resource management plans and activities for intensive land management. A review of historic approaches to integration led us to formulate six principles of wildlife habitat integration with timber management. The application of four of these principles to an actual piece of land shows that there is a practicable method for implementing new laws, policies, and directions. This example dealt with only two of the many resources that must be integrated. The approach can be expanded to encompass all the resources and when used with stand prescriptions and monitoring can serve as a continual means for achieving integrated resource management.

While planning is a major activity of any resource agency, the personnel available to do detailed planning, or to do project implementation, are limited both in numbers and by experience. Detailed planning must be balanced with quality implementation at the field level. New legislation was intended to result in better resource conservation, not just in better plans. Since a typical National Forest might have as many as 200 management areas (usually called compartments) it is inconceivable, at present, that detailed management plans could be worked out for all of them. We propose the use of analysis methods such as presented here to assist resource specialists in implementing a general land management plan on the smaller land units.

A key goal in implementing large scale plans, and in ecosystem management, is to meet current objectives while maintaining future options. This may be a simple approach, but ecosystem management must begin simply. Concepts like diversity and indicator species are just now being applied extensively. Like the notion of a fully regulated forest they are directional guides. But, we don't know exactly how to achieve them. The Forest Service is developing and applying Wildlife and Fish Habitat Relationships models (Salwasser et al. 1981) as the principal analytical tools in establishing habitat criteria for use in land allocations, activity schedules, and stand prescriptions. They are useful in much the same way as a forester uses yield tables. We will eventually know more about how to manage ecosystems for a greater variety of products. For now the best we can do (given the state-of-the-art, the numbers of professionals in the field, and their present skills) is to nudge the ecosystem in what we hope is the right direction.

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Integrating Wildlife Habitat Objectives into the Forest Plan

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Introduction

The National Forest Management Act (NFMA) of 1976 (16 U.S.C. 1600) requires that each National Forest, by 1985, prepare one integrated management plan which provides for multiple use and sustained yield for goods and services (36 CFR 219). "Multiple use", in part, means: "the management of all the various renewable surface resources of the national forests" (including range, timber, watershed, wildlife and fish and outdoor recreation) so that they are utilized in the combination that will best meet the needs of the American people [16 U.S.C. 531(a)]. The Forest Service Chief decided that "the combination" would reflect a quantitative integration of the multiple uses (outdoor recreation, range, timber, watershed and wildlife and fish [16 U.S.C. 531(a)]) and that linear programming (LP), a mathematical optimizing process (Kent 1980) would be used to achieve such integration at the National Forest level (Leitz 1979).

The Arapaho and Roosevelt National Forests Draft Forest Plan is among the first of the integrated forest management plans being completed in response to NFMA requirements. This paper discusses the following aspects of that plan:

1. Requirements for quantitative, integrated, multiple use planning.
2. Wildlife habitat objectives used in planning for the coniferous forest community.
3. Resource allocation and scheduling relative to wildlife habitat objectives.

Forest Setting

The Arapaho and Roosevelt National Forests encompass approximately 1.5 million acres (600,000 ha) in north-central Colorado. Of the Forests' 880,000 acres (352,000 ha) of coniferous vegetation, 51 percent is lodgepole pine *(Pinus contorta),* 23 percent is Douglas fir *(Pseudotsuga menziesii)* and ponderosa pine *(Pinus ponderosa),* and 22 percent is spruce *(Picea engelmannii)* and subalpine fir *(Abies lasiocarpa)*.

Habitat diversity (the variety of different vegetative successional stages) in the forest is low. Most pine and Douglas fir stands are mature or overmature. In at least 11 major watersheds where timber harvest has been concentrated, early forest successional stages are in excess and late successional stages are lacking. Spruce, subalpine fir, and lodgepole pine are the major species affected.

Approximately 414 vertebrate species occur on the forests. Twenty percent are mammals and 61 percent are birds. Forest dependent terrestrial game species are associated most closely with early forest succession; however most forest dependent terrestrial vertebrates, primarily non-game species, are more commonly associated with late forest succession.

Planning Requirements

The Integration Problem

Each of the five multiple use resources has a specific management goal and set of management requirements stated in 36 CFR 219 or in the Forest Service Manual. Each goal, emphasized to the extreme, potentially excludes the others. Simultaneous maximization of these five potentially exclusive or competing goals, through mathematical means, is impossible (see Clawson 1975). Quantitative integration of all the goals and requirements, allowing opportunities for emphasis of a single goal while satisfactorily maintaining the rest, is achieved by stating thresholds or standards for some minimum, biologically required, or socially demanded condition for each (Clawson 1975). Any one resource then, can be emphasized to the extent that the thresholds for the others are not violated.

Process Requirements

Quantified, integrated, multiple use planning requires minimum management standards for each multiple use resource. These standards, stated as minimum thresholds of resource use, are based on public issues and management concerns and reflect law and regulations. Integrated multiple use planning also requires delineation of the "decision space" (Figure 1) or the bounds of multiple use management opportunity. This space is bounded by minimum and maximum constrained levels of management for each resource. Multiple use management alternatives come from the decision space and provide integrated mixes of resource outputs where all multiple use resources are adequately represented.

Wildlife Habitat Objectives

Objectives for threshold or minimum acceptable wildlife habitat conditions were stated for all major ecosystems to assure that the wildlife resource would be adequately considered under all management emphases. Objectives for the most desirable habitat conditions were also stated to provide direction for future management.

Two kinds of wildlife habitat objectives were stated in the planning process:

1. Those that served as either constraints (minimum acceptable conditions) or objective functions (optimum condition) in the LP resource allocation model.
2. Those that provided direction for project planning outside the modeling process.

Those used in the LP specified the acceptable range of proportions of forest habitat necessary and sufficient to meet wildlife habitat requirements. Derivation and application of these objectives are discussed below. Objectives providing direction for project planning including considerations of edge, edge contrast, thermal and hiding cover, riparian zones, snags, dead and down woody material, burrows, caves, cliffs, rimrock, talus and "open" road density are presented in the Forest Plan (USDA Forest Service, in prep.).

Wildlife Goal

Habitat objectives reflect requirements of the wildlife goal. The goal has four distinct aspects:

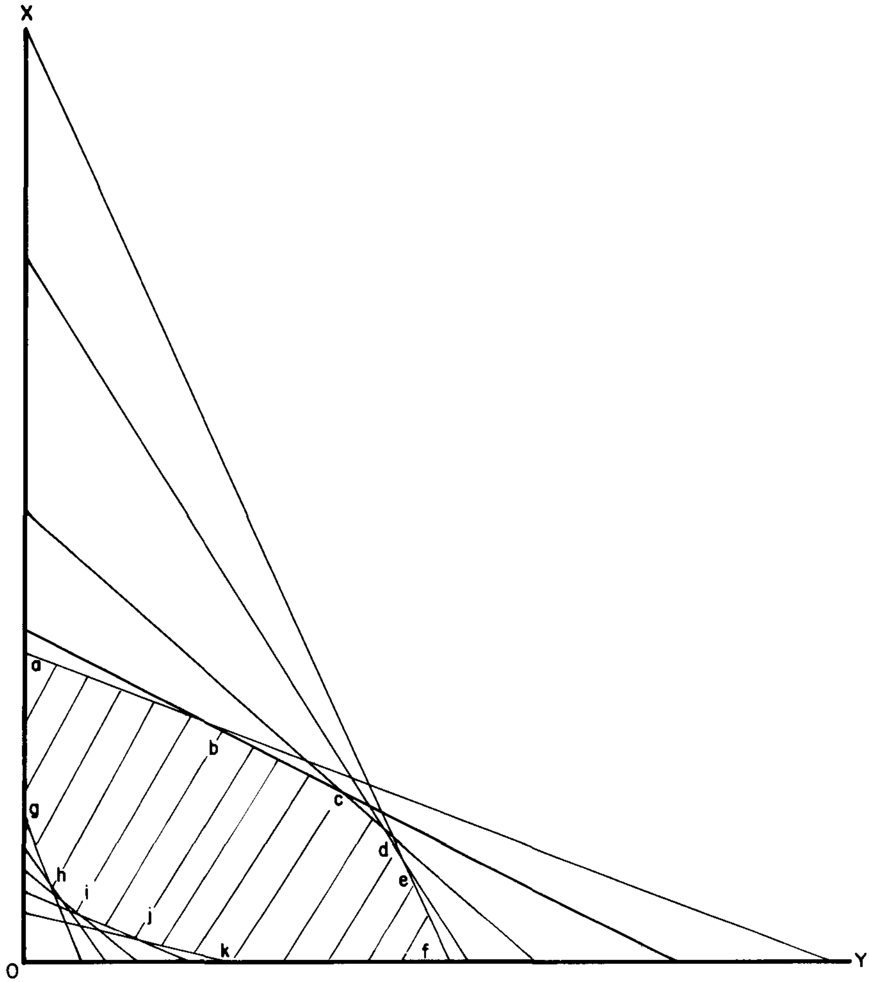

Figure 1. Intersection of graphs of linear equations showing maximum constrained management level (a, b, c, d, e, f) and minimum constrained management level (g, h, i, j, k) which delineate decision space (shaded area). Lines represent minimum and maximum levels for each of the multiple-use resources. Management at any point outside the decision space would represent a non-integrated mix of outputs inconsistent with multiple use principles.

1. " . . . wildlife habitat will be managed to maintain viable populations of all existing native vertebrates in the planning area (36 CFR 219.12)." This aspect relates to ecosystem principles and concepts pertaining to organization at the biotic community level (Odum 1971). Thomas (1979) has referred to this aspect as "management for species richness." Species richness management requires that the highest possible number of resident species be maintained in viable numbers.

2. ". . . maintain and improve habitat of management indicator species (36 CFR 219.12)." This aspect relates to ecosystem principles and concepts pertaining to the species and the individual in the ecosystem (Odum 1971). Thomas (1979) has referred to this aspect as "management for featured species." Featured species management requires the production of desired species (one or several) in appropriate locations and numbers
3. "Provide for and maintain diversity of plant and animal communities to meet overall multiple use objectives (36 CFR 219.13)." Diversity, the distribution and abundance of different plant and animal communities and species in the planning area (36 CFR 219.3), must be provided in maintaining viable populations of all vertebrates and in maintaining and improving habitat of management indicator species. Where appropriate and practicable, diversity, at least as great as that which would be expected in a natural forest, should be provided (36 CFR 219.13).
4. "Provide wildlife and their habitat on a sustained-yield basis (16 U.S.C. 528-531)." The "stable flow" annual-increment concept applies to wildlife and their habitat just as it does to other National Forest resources. Since habitat manipulation for wildlife is most often related to vegetation manipulation, such manipulation must reflect the sustainable annual increment of the vegetation.

Management Indicator Species

Management indicator species (MIS) were selected using criteria in 36 CFR 219.12(g) and in Odum (1971:138-139). MIS were used for planning because development and use of equitable habitat objectives for all 414 vertebrates was impractical. Primary factors in selection were the needs to maintain viable populations of all vertebrates and to provide diversity.

It was assumed that the majority of forest related species find optimum habitat conditions in either early or late successional stages (Hall and Thomas 1979). At least there were no vertebrate species with apparent obligate dependencies on the sapling, pole or young timber successional stages (USDA Forest Service 1980). Associations of vertebrate species, related primarily to either the grass/forb/shrub stage (early forest succession) or the mature and old growth stages (late forest succession) were selected which represent or indicate the effects of management upon other vertebrates similarly adapted (Table 1). Members of associations of species were used as indicators in order to represent a variety of ecological niches within a general habitat type. Associations of species were assumed to more reliably reflect the effects of management upon other species and their habitat than single, unrelated species (Odum 1971).

Habitat objectives representing the needs of the two associations of indicator species were stated as proportions of forest successional stages, and numbers of residual trees per acre by size class. They were based on the habitat requirements of elk *(Cervus elaphus)* representing the early forest succession MIS, and the three accipiters: goshawk *(Accipiter gentilis)*, sharp-shinned hawk *(Accipiter striatus)*, Cooper's hawk *(Accipiter cooperii)*, representing late forest succession MIS. Elk were represented because of their large space and food needs. Accipiters were represented because of their large space needs and nesting and foraging habitat requirements. It was assumed that habitat objectives compatible with the needs of

Table 1. Associations of management indicator vertebrate species for the Arapaho and Roosevelt National Forests.[a]

Early forest succession indicator animal association (common name)	Late forest succession indicator animal association (common name)
Elk	Goshawk
Mule deer	Sharp-shinned hawk
Deer mouse	Cooper's hawk
Gray-headed junco	Northern three-toed woodpecker
Ground squirrel	Ruby crowned kinglet
	Red backed vole
	Tree squirrel

[a]Threatened, endangered and sensitive species as well as species commonly hunted, fished or trapped supplemented the associations as management indicator species.

species with the most restrictive habitat requirements would also accommodate the needs of MIS with similar but less restrictive requirements. Such objectives would accommodate the needs of all MIS and therefore all vertebrates (*See* Canutt and Poppino 1978, Hall and Thomas 1979, Verner 1975).

Elk home range size during summer, the period of widest distribution, was assumed to be 5,000 acres (2,000 ha). The assumed area reflected an average of data describing elk distribution during summer in forested habitats in Oregon, Idaho, Montana and Wyoming (Pedersen et al. 1980, Marcum and Lehmkuhl 1980, Lonner and Hammond 1980, Cada 1978, Craighead et al. 1973, Hash 1973). Nesting density of each of the three species of accipiters was assumed to be approximately one pair per 5,500 acres (2,200 ha). The assumed area reflected an average of data describing goshawk nesting density in Colorado (Shuster 1977) and Cooper's hawks and sharp-shinned hawks in Oregon (Reynolds 1979).

Habitat objectives applicable to all forested areas and pertaining to elk, accipiters and all other vertebrates, were calculated as percentages of 5,000 acres. Primary justification was the requirement to maintain and improve habitat for MIS. Since elk and accipiters are adapted throughout the Forests to units of approximately 5,000 acres (2,000 ha) and require habitat suitable year-long to their mobility, it was assumed that all habitat maintenance and improvement activities must be based on objectives reflecting a correlation of use patterns related to food, cover, water, reproduction and space. Additional justifications were the requirements to maintain viable populations of native vertebrates and to provide for and maintain diversity in animal communities. Relatively large breeding populations or gene pools are necessary to meet these requirements because they maintain high levels of heterozygosity or opportunities to increase heterozygosity (Soule 1979, Mayr 1976), and reduce the incidence of inbreeding (Soule 1979, Keeton 1967). Habitat objectives expressed as proportions of discrete land units used by MIS, are compatible with such conditions. This approach has precedence in northeastern Oregon where four National Forests stated wildlife habitat objectives relative to 5,000-6,000 acre (2,000-2,400 ha) units (Miller 1978).

Minimum proportions of habitat necessary to provide for threshold populations of accipiters and elk on 5,000 acres (2,000 ha) and opportunities to emphasize conditions for one or the other are shown in Figure 2. One thousand acres (400 ha)

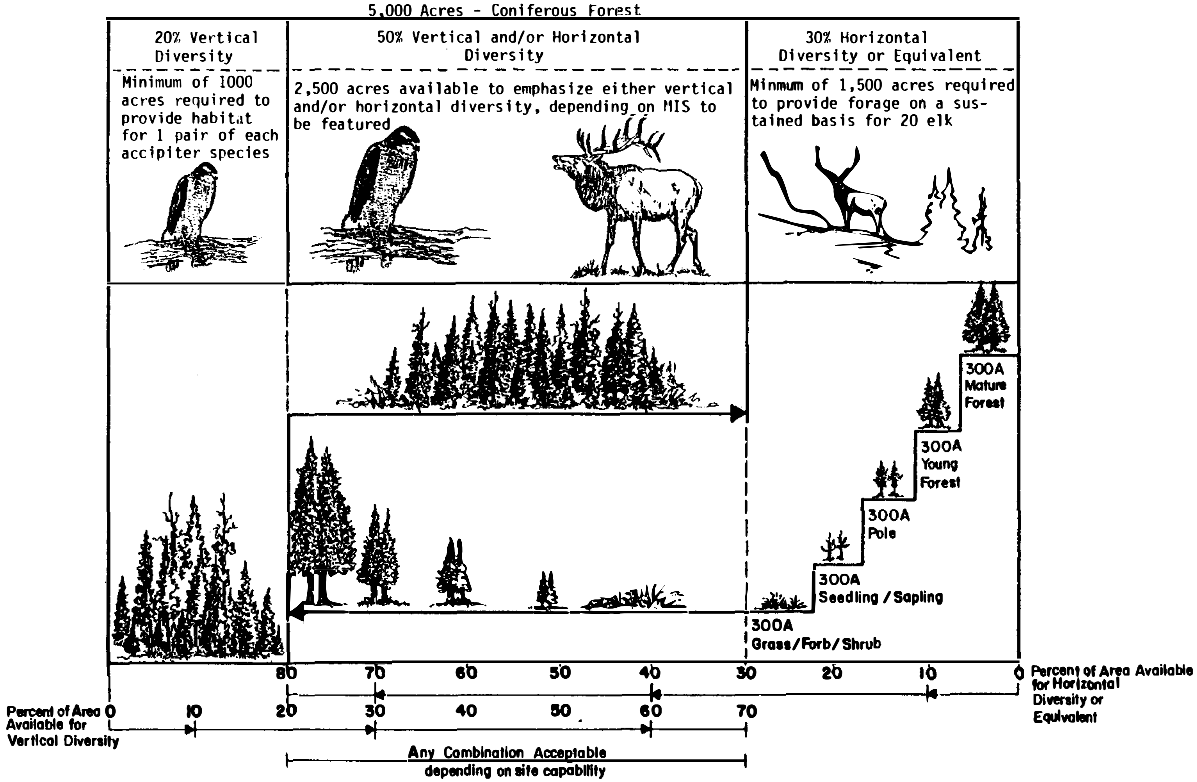

Figure 2. Proportions of habitat to accommodate at least threshold populations of management indicator species and emphasize habitat conditions for different management indicator species.

(20 percent of any area 5,000 acres or greater) of mature forest with a high degree of vertical vegetative diversity were assumed necessary to provide habitat for one breeding pair of each of the three accipiter species (Mealey and Horn 1981). Old growth was judged a desirable but not necessary component of the vegetation requirement. Conditions assumed to be necessary were three canopy layers, including the seedling, pole and mature (9-24 inches [22.5-60 cm] dbh) size classes, and snags occurring within each stand.

Uneven-aged silviculture (36 CFR 219.3; Alexander and Edminster 1977) was determined appropriate to establish or maintain these conditions in spruce and subalpine fir. Group selection and individual tree selection were assumed to enhance vertebrate species diversity in general and bird species diversity in particular (Smith 1980, Alexander 1977). An acceptable way to maintain or establish these conditions in lodgepole pine, Douglas fir and ponderosa pine was to increase the rotation ages of the coniferous species (see Diem and Zeveloff 1980, Hall and Thomas 1979).

Fifteen-hundred acres (600 ha) (30 percent of any area 5,000 acres or greater) under even-aged silviculture (36 CFR 219.3) with five structural stages, a 120 year rotation cycle, and a high degree of horizontal vegetative diversity were assumed sufficient to provide most of the year-round food needs for 20 elk (Mealey and Horn 1981). Fifteen hundred acres under uneven-aged silviculture (Alexander and Edminster 1977) were assumed sufficient also, to provide, through induced openings ecologically equivalent to the grass/forb/shrub stage, most of the year-round food needs for 20 elk (*See* Patton 1976). Silvicultural objectives for residual growing stock, diameter distribution and maximum tree size would emphasize herbage production rather than vertical layering of foliage. At least one of the systems was assumed necessary to provide elk food needs.

Habitat objectives for 50 percent of any area 5,000 acres (2,000 ha) or greater were fixed, to provide habitat for at least threshold populations of elk and accipiters and species represented by them. Habitat objectives for the remaining 50 percent were assumed to be necessary since space requirements of the most mobile species related to the entire 5,000 acres as did the food, cover, water and space requirements for all other vertebrates. Objectives were variable depending on the coniferous species present and their amenability to even-aged and uneven-aged silviculture, or horizontal and vertical vegetative diversity.

Habitat Objectives Summary

The general wildlife habitat objective for coniferous forests follows:

> Management activities changing current conditions will, in the earliest feasible time, maintain or establish vertical diversity in a minimum of 20 percent of the forest area and maintain or establish horizontal diversity in a minimum of 30 percent of the forest area. In the remaining area, emphasize vertical and/or horizontal diversity.

Objectives for optimum vegetation structures, where any or all of lodgepole pine, Douglas fir and ponderosa pine predominated, were: 20 percent vertical diversity and 80 percent horizontal diversity. Objectives applied to the total forested area. Habitat objectives for each coniferous species are shown in Table 2. Objectives

Table 2. Minimum and optimum habitat objectives for lodgepole pine, Douglas fir and ponderosa pine expressed as proportions of successional stages.

Lodgepole pine			
Successional Stage	Minimum standards	Optimum conditions	
		Case 1[a]	Case 2[b]
Grass/forb/shrub	High range ≤ 20%		
	Low range > present if present is < 20%	16%	20%
Seedling/sapling	—	16%	20%
Pole	—	16%	20%
Young	—	16%	20%
Mature	20% ± 5	16%	20%
Old growth or vertical diversity	≥ 20%	20%	—

Douglas fir and ponderosa pine			
	Minimum standards	Optimum conditions	
		Case 1[a]	Case 2[b]
Grass/forb/shrub	High range ≤ 31%		
Seedling/sapling	Low range > present if present is < 31%	25%	31%
Pole	—	25%	31%
Young Mature	35 ± 5%	30%	38%
Old growth or vertical diversity	≥ 20%	20%	—

[a]Applicable if species is generally continuous and vertical diversity cannot be provided on lands unsuitable for harvest operations, on lands constrained for other purposes such as edge and riparian management, or in spruce and subalpine fir or other coniferous species.
[b]Applicable if species is not generally continuous and vertical diversity can be provided on lands unsuitable for harvest, on lands otherwise constrained or in spruce and subalpine fir or other coniferous species.

applied only to that portion of the forested area where the respective species occurred.

Minimum standards (Table 2) reflect habitat conditions that must be maintained or established if current conditions are changed through management. Standards would maintain or establish habitat for at least minimum viable populations of all vertebrates and maintain and improve habitat of MIS to provide for at least viable populations. Specific objectives were stated only for early and late forest successional stages, because, as discussed previously, most species appeared to be adapted primarily to one or the other. It was assumed that unconstrained proportions of intermediate stages, resulting from LP allocation, would be at least marginally acceptable as wildlife habitat. Objectives for optimum conditions reflect the sustainable future condition of the forest that would provide optimum habitat for elk and other MIS oriented primarily to early forest succession and maintain acceptable habitat for species adapted primarily to late forest succession.

Objectives for optimum vegetation structure where spruce and subalpine fir predominated were: 70 percent vertical diversity and 30 percent horizontal diversity. Horizontal diversity could be provided in pine or Douglas fir stands through even-aged silviculture or in spruce-fir stands through group or single tree selection cuts emphasizing herb production. Vertical diversity would be established or maintained by providing three canopy layers, as previously discussed, with residual numbers of trees per acre, plotted over diameter classes, resulting in a typical inverse "J" shaped curve (Alexander and Edminster 1977).

Optimum conditions were defined by the inverse "J" shaped curve with diameter classes ranging from 2-24 inches (5-60 cm) and reflect the future forest condition that would emphasize habitat conditions for accipiters and other species oriented primarily to late forest succession and maintain acceptable habitat for species adapted to early forest succession. The minimum standard was current stand conditions directed toward optimum.

For all coniferous species, if current vegetation conditions were within or equal to limits of habitat objectives and management was planned, conditions directed toward optimum were required over the 50 year planning period. If current conditions were outside limits and management was planned, conditions compatible with limits were required as a first priority. Conditions directed toward optimum were required as a second priority.

The Forest Plan requires "on site" monitoring to determine the degree of conformity of future silvicultural projects with minimum and optimum habitat objectives and objectives for project planning. Monitoring of MIS populations is also required to determine population response to habitat conditions resulting from plan implementation. Refinement of habitat and project planning objectives is required to assure attainment of the wildlife goal.

Modeling Wildlife Habitat Objectives

Process Overview

Two linear programming models (Horn, in preparation), one driving the other, were used to determine the optimum, integrated multiple use output levels for the Forests. In considering wildlife habitat objectives, a primary model allocated and scheduled non-contiguous homogenous timber stands, on a forest-wide basis, for silvicultural treatment which provided horizontal or vertical diversity in response to constraints (minimum standards) and goal equations (optimum conditions) (Table 2). An auxillary model responding to the same habitat standards and conditions disaggregated the forest-wide solution to fourth order watersheds (areas averaging approximately 15,000 acres [6,000 ha]) on the basis of stand conditions, habitat needs and other resource conditions within each watershed. As a result, site-specific allocation and scheduling was compatible with resource capability and requirements. In both models, different allocation priorities were assigned to stands depending on their occurrence in big game winter range or in non-roaded areas. These priorities forced allocation sensitivity to habitats with different ecologic and economic significance.

Over the 50 year planning period, the primary and secondary models forced habitat structure to move incrementally toward optimum conditions while maintaining minimum standards for wildlife and all other resources. During each time period, the acres deviating from optimum habitat conditions decreased (Figure 3).

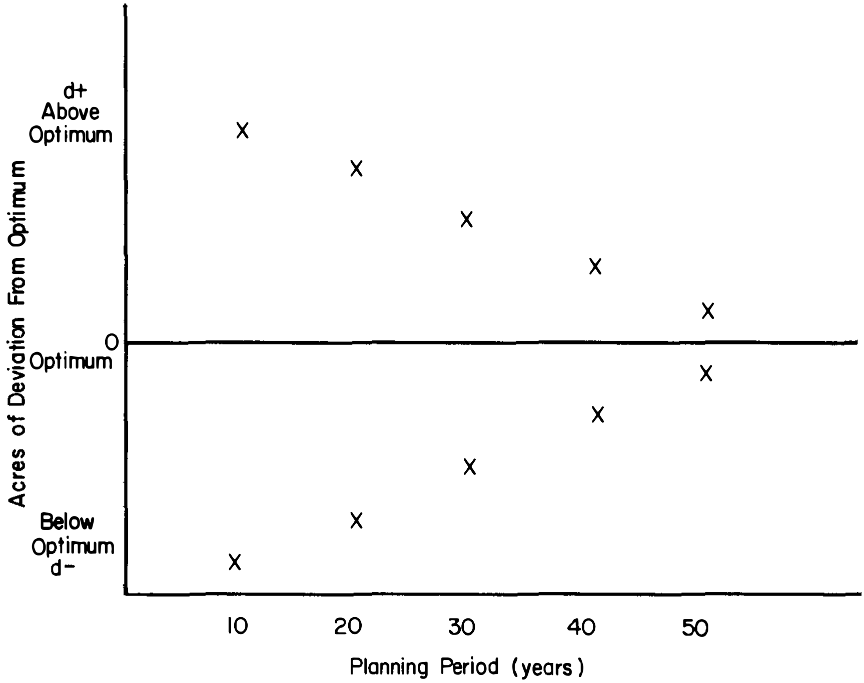

Figure 3. Incremental reduction in deviation of habitat conditions from optimum habitat conditions.

This was achieved by placing constraints, during each time period, on the amount of deviation from the optimum. In watersheds where mature or overmature timber predominated, the proportion of early forest successional stages was increased. In watersheds where timber harvest has been concentrated, the proportion of late forest successional stages was increased.

An Example: The Willow Creek Area Watersheds

Preliminary allocation and scheduling of management prescriptions to timber stands in five watersheds in the Willow Creek area of the Forests was done to test the compatibility of modeled outputs with site- or area-specific resource conditions and needs. Watersheds varied in size from 26,414 acres (10,565 ha) to 6,882 acres (2,752 ha). Lodgepole pine was the predominant species in all watersheds.

Any of the forested acres allocated by stand to silvicultural treatment in the primary, forest-wide model were available to the auxillary model in meeting area-specific habitat needs. Area wide vegetation structure objectives were: 20 percent vertical diversity and 80 percent horizontal diversity. Optimum conditions, case 2 (Table 2) served as an objective function in the auxillary model. Old growth or vertical diversity was not constrained because of its sufficient availability in spruce-fir and forested areas unavailable for harvest. Current, projected and optimum proportions of forest successional stages resulting from modeled allocation and

Table 3. Current, projected and optimum proportions of forest successional stages resulting from linear programming model allocation and scheduling of timber stands to management prescriptions in 5 watersheds in the Willow Creek area.

	Watershed #1				Watershed #2				Watershed #3				Watershed #4				Watershed #5			
	Current	10 Years	50 Years	Optimum	Current	10 Years	50 Years	Optimum	Current	10 Years	50 Years	Optimum	Current	10 Years	50 Years	Optimum	Current	10 Years	50 Years	Optimum
Grass/forb	0.0	5.3	6.9	20	0.0	4.3	7.8	20	0.0	3.9	13.0	20	0.0	2.3	7.7	20	0.0	1.3	2.3	20
Seedling/sapling	35.2	30.3	20.6	20	45.8	42.6	9.3	20	65.2	58.1	10.6	20	57.8	53.9	15.6	20	46.9	45.6	6.4	20
Pole	38.0	32.7	39.5	20	40.1	38.8	47.1	20	27.6	24.5	65.2	20	29.6	27.6	57.4	20	41.6	40.0	53.2	20
Young and mature forest	26.8	31.6	33.0	40	14.1	14.4	35.7	40	7.2	13.5	11.2	40	12.6	16.2	19.3	40	11.6	13.1	38.1	40

scheduling are shown in Table 3. Current conditions show an excess of the seedling/sapling stage and a shortage of the young and mature forest stages. This indicates the effects of timber harvest activities which were concentrated in the watersheds, primarily during the 1960s. Habitat conditions resulting from allocation, projected over the planning period, show a strong movement toward optimum, and the establishment of habitat conditions compatible with the wildlife management goal. Silvicultural practices emphasized thinning and partial removal while allowing existing stands to mature. Objectives for project planning required proper spatial arrangement of stands and provision for special and unique habitats.

Acknowledgements

C. W. Rupp, Regional Forester, and W. B. Gallaher, Director of Range and Wildlife Management, both of the Rocky Mountain Region, U.S. Forest Service, strongly encouraged and supported process development. Forest Supervisors and resource staff personnel of the Shoshone and Arapaho and Roosevelt National Forests made major conceptual and technical contributions. M. Barker, J. Cruse and L. Strecker played major roles and were especially innovative. Personnel of the Wyoming Game and Fish Department and the Colorado Division of Wildlife participated actively and made many useful suggestions. We are grateful for the special assistance of the following people in the preparation and critical review of this paper: P. T. Haug, B. M. Kent, R. T. Reynolds, D. L. Schweitzer, D. R. Smith, J. W. Thomas, and W. L. Webb.

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Use of Forest Simulation Models to Integrate Timber Harvest and Nongame Bird Management

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Introduction

The loss of habitat from past and present forest management practices has resulted in a growing concern among wildlife biologists. Much of this interest has been focused on the nongame bird component of the animal community (Smith 1975, DeGraaf 1978). Researchers have attempted either to define the general habitat requirements of selected species or the role of structural heterogeneity on the overall avian diversity of the forest (MacArthur and MacArthur 1961). This information, coupled with a knowledge of the effects of various silvicultural practices on the vegetational structure of the forest, has been the basis for predicting the effects of timber management on the availability of avian habitat. This approach is generally of a qualitative nature and usually considers only the presence or absence of a given species under the proposed management scheme. The purpose of this paper is to introduce a methodology for predicting habitat availability under various forest management schemes on specific forested sites through the use of habitat simulation models.

Habitat simulation models integrate the use of habitat classification with the predictive ability of the forest simulation model (Shugart and West 1980). This process involves (a) the structural classification of forest stands in terms of suitability to provide habitat for a given animal species, and (b) a forest simulator with the ability to generate the specific structural variables on which the classification is based. By introducing proposed management strategies to the model, we can evaluate the long-term effects of timber harvest on the availability of habitat for a specific avian species.

Examples will be presented of two forest simulation models used to predict available habitat for their corresponding avian communities. FORLOB, a loblolly pine simulation model, was used to simulate loblolly pine stands in Arkansas to assess the effects of different forest management strategies on the availability of nesting sites for the red-cockaded woodpecker. A second model, FORHAB (a deciduous forest succession model), was used to predict changes in the structure of the avian community on the Walker Branch Watershed in east Tennessee resulting from simulated timber management practices.

The General Form of the Model

Both FORLOB and FORHAB simulate the annual change of a forest stand (one-fifth acre, one-twelfth hectare circular plot) by calculating the growth increment of each tree on the stand (subroutine GROW), by tabulating the addition of new saplings to the stand (subroutines BIRTH and SPROUT), and by tabulating the death of trees present on the stand. These processes are simulated based on general silvicultural information including: site requirements for germination, palatability of seeds to browsers, sprouting potential, shade tolerance, germination and growth temperature requirements, inherent growth potential, longevity, and sensitivity to crowding stress. The maximum growth of each tree on a plot is computed from the inherent radial and height increment potential and longevity of the tree species. This maximum growth is modified by the response of the tree to such environmental conditions as light availability, annual temperature and growing degree days, spatial crowding, and root competition. These environmental factors are considered to be homogeneously distributed over the plot (Shugart and West 1977). Seed and sprout establishment is based on the availability of light, proper temperatures, substrate requirements for germination, and sprouting capabilities of dying trees. Mortality is a function of the growth and expected maximum age of the tree. Each growth response to environmental conditions is described as a probability function. Therefore, the models are of a stochastic nature, allowing for a wide variation in the response of any individual tree. Provided that the mean and variance of the biological response of an individual tree to a management technique are known, the model can be used to simulate the subsequent effect on the forest community. The inclusion of such disturbances into the dynamics of the forested communities simulated by both FORLOB and FORHAB and their subsequent effect on the availability of avian habitat will be discussed in the following sections.

FORLOB: A Loblolly Pine Simulation Model

FORLOB is a modified version of FORAR (Mielke et al. 1978) and simulates a loblolly pine forest on upland forest sites typical of south central Arkansas. The model was used to determine the effects of various forest management schemes on both the availability of red-cockaded woodpecker *(Picoides borealis)* nesting sites and timber production.

The red-cockaded woodpecker was once widespread in the southern pine forests ranging along the eastern states from southern Virginia to Florida and west to Arkansas, Louisiana, and eastern Texas (Jackson 1971). In recent years, however, the distribution of the red-cockaded woodpecker has steadily declined to only a fraction of its previous range. Although some of this habitat loss can be attributed to fire prevention policy and the subsequent increase of hardwood cover, the major factor is the decline in the number of older pine trees used by the birds for the excavation of nest cavities (Thompson and Baker 1971). This decline is due to present timber management practices which find it economically advantageous to harvest the trees before they reach the age at which birds find them favorable for the excavation of cavities.

The red-cockaded woodpecker prefers mature pine stands with a low (< 5 ft, 1.52 m.) sparse understory (Crosby 1971, Jackson 1977). Home ranges of a single pair usually range between 35 to 50 acres (14.2 to 20.2 ha), although a colony of up to eight breeding pairs may have a home range of 200 acres (81 ha). Inside the smaller nesting sites, the birds select live pine trees infected by red heart fungus *(Fomes pini)* in which to excavate their nest sites (Steirly 1957). The age of trees with cavity starts varies with species, but nest cavities are rarely found in trees younger than 60 years (Hopkins and Lynn 1971, Jackson et al. 1979).

The model was used to simulate several management strategies (Table 1) consisting of thinning and controlled burning at different stand ages. All stands were "planted" with an initial stocking density of 1,500 stems per acre. At year 100 all stands were clearcut independent of previous management. It was assumed that the stand was unsuitable as red-cockaded woodpecker habitat until at least year 60. Habitat was further defined as low stocking density (preferably less than 80 ft^2 per acre) and low or non-existent understory.

Results and Discussion

Table 1 shows the results of five simulated management schemes. Each simulation was for a period of 100 years, at which time the plots were clearcut. The five management schemes reflect various cutting schedules with periodic burning to clear the understory of hardwood invasion. Timber production is expressed as average basal area and number of trees removed per one-fifth acre stand over all cuts. The availability of potential nest trees is expressed as the average number and basal area of the trees greater than 60 years of age on the plots at year 100.

Results (Table 1) show that management scheme number 3, which involved cuts at years 25, 40, and 60 to a basal area of 80 ft^2 per acre, gave maximum timber production as well as availability of potential nest trees. Management scheme number 2, which involved only a thinning cut at year 60, resulted in older and larger potential nest trees, but timber yield in both number of trees and basal area were considerably less. Management scheme number 1, in which there was no thinning or burning prior to clearcut, resulted in the largest available nest trees. In this case, however, the understory was very dense (as a result of no burning over the 100 year simulation) and would potentially limit the use of these trees as nest sites.

Despite the wide variation in timber production for the various management schemes, the variation in cutting schedules appears to have only a limited effect on the availability of potential nest trees. This may very well be misleading. The number and size of potential nest trees may not necessarily reflect their quality and ultimate use as nesting sites. Also the suitability of a tree is dependent on the presence of red heart fungus, a factor very much related to the age of the tree. The model does provide a means by which various management schemes can be assessed as to their potential to maximize timber production as well as provide habitat for the red-cockaded woodpecker.

FORHAB: An Eastern Deciduous Forest Habitat Simulation Model

FORHAB is a modified version of FORET (Shugart and West 1977), an Appalachian deciduous forest stand simulator. A detailed description of the model (FORET) can be found in Shugart and West (1977). FORHAB was used to predict the impact of certain forest management decisions on the availability of breeding habitat for the avian community inhabiting the Walker Branch Watershed in east Tennessee (for a detailed description of the site see Grigal and Goldstein 1971). Those subroutines involved in the management and classification of simulated stands will be discussed separately.

Table 1. Results of FORLOB for five simulated forest management schemes.

Type of Management	Mean basal area removed[a]	Mean number of trees cut[a]	Number of potential nest trees at year 100[a]	Mean basal area of nest trees
Scheme No. 1 No thinning cuts. No fire. Clearcut at year 100.	81.11 ft^2	17.0	17.0	4.77 ft^2
Scheme No. 2 Thinning at year 60 to basal area of 80 ft^2 per acre. Periodic fire. Clearcut at year 100.	120.91 ft^2	30.5	16.5	3.96 ft^2
Scheme No.3 Thinning at years 25, 40 and 60 to a basal area of 80 ft^2 per acre. Periodic fire. Clearcut at year 100.	206.35 ft^2	187.0	19.5	1.10 ft^2
Scheme No. 4 Thinning at years 30, 45 and 60 to a basal area of 80 ft^2 per acre. Periodic fire. Clearcut at year 100.	169.68 ft^2	137.0	13.0	1.24 ft^2
Scheme No. 5 Thinning at years 25, 40 and 60 to a basal area of 60 ft^2 per acre. Periodic fire. Clearcut at year 100.	165.54	225.0	15.5	0.74 ft^2

[a]Values expressed on a per acre basis.

Subroutine CUT

The CUT subroutine simulates various forest management practices which are applicable to the southeastern deciduous forest type. The version of this subroutine used for the following analysis was a diameter-limit cut. In this subroutine all commercially valuable species for saw timber greater than 11 inches (28 cm) dbh were removed from the plot on a 60-year rotation. The rotation period of 60 years was determined by analysis of stem and basal area curves generated by FORHAB after initial simulations of logging on the watershed.

Subroutine HABIT

The process of classifying stands as to their potential to provide habitat for a given species is carried out in subroutine DISCRM. The classification is based on a set of biomass variables which describe the vegetational structure of the forest stands. Model output, in the form of species and tree diameters, must therefore be used to calculate these biomass variables.

The HABIT subroutine divides all trees on the simulated plot into two groups, conifer and deciduous, and then into three size classes within each of these two groups. The foliage, branch, and bole biomass for each tree is then calculated using regression equations which are site specific to the Walker Branch Watershed (Harris et al. 1973). These values are then summed for all trees on a plot for each class to provide the above-mentioned variables.

Subroutine DISCRM

The classification of simulated forest stands as potential habitat for a given bird species is carried out in subroutine DISCRM. The classification is based on the statistical procedure of two-group discriminant function analysis (Morrison 1967). Classification criteria were constructed using the vegetational data collected on 298 one-fifth acre (one-twelfth hectare) permanent census plots. Breeding territories of the various bird species which either contained or overlapped any of the 298 plots were located and mapped. If a plot was located within a territory of an individual bird (breeding pair), the plot was considered as potential habitat for that species. Conversely, if a given plot was not within the boundary of a territory of that species, the plot was classified as not providing habitat for the species. Thus, data were obtained on areas of both suitable habitat as well as areas that were not used by the various bird species. Data on the vegetation of these census plots, in the form of species and diameter for each tree on the plot, were then used to generate the biomass variables for classification using the same regression equations as those in subroutine HABIT. This data set was then used to construct linear decision scales, a classification scheme using the Bayes or minimum loss classification rule, based on two-group discriminant function analysis (Smith et al. 1981). Subroutine DISCRM consists of a series of linear decision scales, one corresponding to each bird species comprising the avian community. Each simulation plot is input into subroutine HABIT, where the biomass variables necessary for the classification are generated. These variables are then input into subroutine DISCRM, where a decision is made as to whether that plot provides potential breeding habitat for each of the species.

Results and Discussion

Figure 1 shows the dynamics of the forest structure from 120-year simulations of the Walker Branch Watershed. Forest structure is expressed as the average number of stems, foliage and branch biomass over all species per one-fifth acre. Year zero represents the structural configuration of the present forest on the watershed. This was accomplished by initializing the model with 298 randomly chosen census plots from the watershed using the vegetation data collected on those plots in 1977. Results are given for both timber management and undisturbed conditions. Sawtimber cuts were made at both year 1 and 60 of the simulation, which can be seen from the reduction in number of stems, foliage and branch biomass for the greater than 9-inch (22.8 cm) size class of trees.

Figure 2 shows the availability of potential breeding habitat for the red-eyed vireo *(Vireo olivaceus)* and ovenbird *(Seiurus aurocapillus)* for the same 120-year simulations. The red-eyed vireo showed a steady decrease in habitat availability under undisturbed conditions until approximately year 90. At this time there was only a slight increase in habitat to 10 percent of the total land area of the watershed. Results of the simulation which included timber harvest diverged from those of the undisturbed forest. The percentage of available habitat declined for the first two years following the initial thinning, after which habitat for the red-eyed vireo increased to a high of 45 percent. This was followed by a continual decline until approximately year 50, at which time the forest was unsuitable as habitat for the red-eyed vireo. Following the timber harvest at year 60, habitat increased to a level between 20 and 25 percent for the next 20 years and declined thereafter.

Results of the simulation of habitat availability for the ovenbird showed a pattern similar to that of the red-eyed vireo, however, it differed in temporal arrangement. The undisturbed simulation showed an initial increase of habitat for the first several years followed by a continual decline until approximately year 50. At this time, habitat for the ovenbird varied between 3 to 12 percent for the remainder of the simulation. The simulation which included timber harvest showed a decline in available habitat during the first five years following the initial timber cut. Over the next 10 years, habitat availability increased to 75 percent before declining to less than 10 percent of the watershed by year 60. Following the second cut, however, there was an increase in available habitat. This initial increase over the first few years after thinning was followed by a slight decline and subsequent increase to over 60 percent available habitat by year 80. This increase was then followed by a decline in habitat for the remainder of the simulation.

In the case of both species, we observed a general increase in the available habitat as a result of timber harvest. This increase contrasts with the decline of habitat availability for the undisturbed simulations. The red-eyed vireo characteristically feeds by gleaning the foliage of insects where the canopy is abundant and the understory is dense (Williamson 1971). The general decline in habitat is a function of canopy closure and the lack of a well-developed understory as the forest increases in age over the simulation. When the canopy is opened after thinning, there is a development of the understory and a subsequent increase in habitat. This can be seen in the increase of stems, foliage and branch biomass following the thinnings at years 1 and 60 in Figure 1.

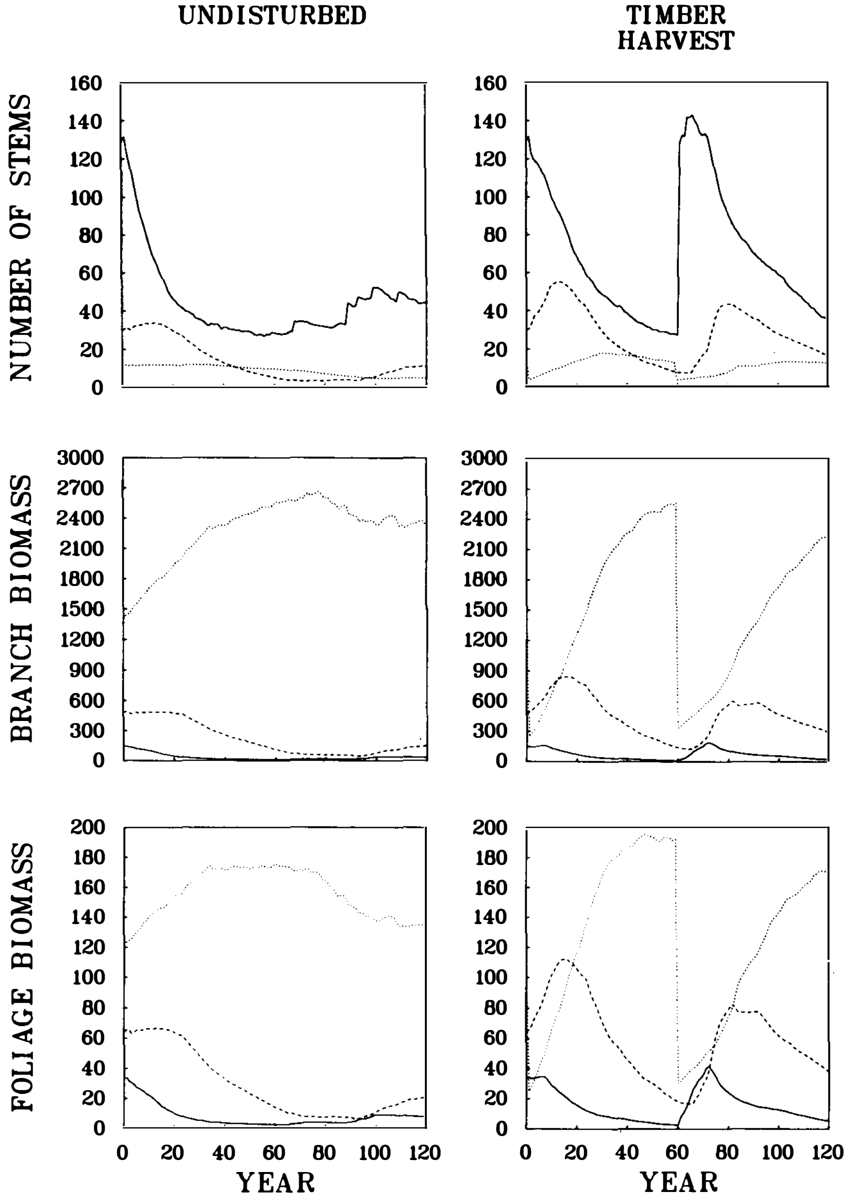

Figure 1. Structural dynamics of the Walker Branch Watershed as predicted by FORHAB for both undisturbed and timber harvest conditions. Biomass measurements are expressed as kilograms dry weight per one-fifth acre. Results are grouped into three size classes: —— less than 3 inches (7.6 cm), --- 3 to 9 inches dbh (7.6 to 22.8 cm), . . . greater than 9 inches dbh (greater than 22.8 cm).

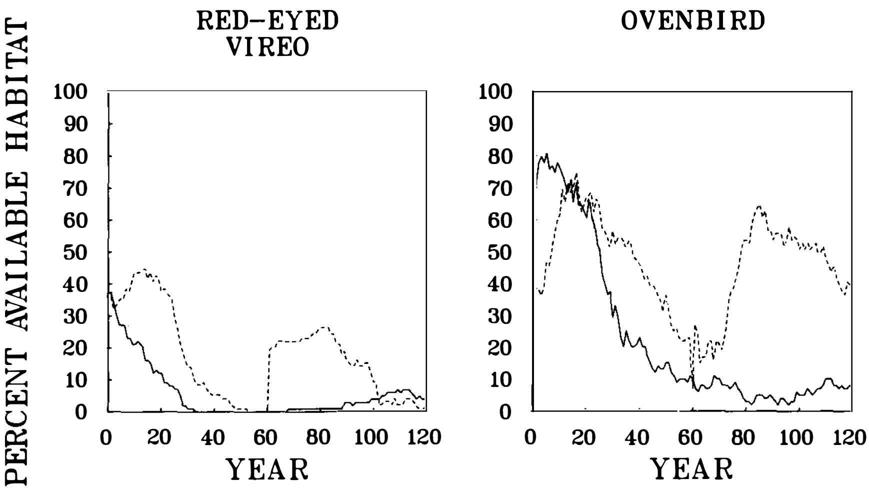

Figure 2. Percentage of available habitat for red-eyed vireo and ovenbird as predicted by FORHAB for both undisturbed and timber harvest conditions. Percentage of available habitat expressed as percentage of the total land area of the watershed. Undisturbed simulations are expressed as a solid line, results of the timber harvest simulations are shown as a dashed line.

A deciduous stand with a well-developed canopy, sparse understory and brush, and little ground cover provides optimal habitat for the ovenbird. The decline in available habitat following the first cut was a result of disturbing what is presently ideal habitat for the ovenbird. However, the effect was short lived as the number of stems in the second (3-9 inch [7.6-22.8 cm]) and third (greater than 9 inch) size classes increased over the next 10 years. As the stand matures and the over-all density of the forest stands increases to a park-like configuration of closed canopy with a very sparse to nonexistent understory (Figure 1), the availability of habitat for the ovenbird decreases. This is the same reason for the continual decline of habitat for the undisturbed simulations. The thinning of the overstory led to an initial increase of habitat, but further increase in the understory and brush reduced available habitat. This increase in the understory and brush, however, is short lived (Figure 1) and habitat availability again increases as the understory and brush decline.

It should be noted that the models presented simulate the availability of potential habitat expressed either as a percentage of the total land area under consideration or the number of potential nest sites. The model does not simulate the population dynamics of a given bird species per se. The ability of the ovenbird population to track changes in the availability of habitat or to reinvade after the elimination of potential breeding habitat in an area is not explicitly considered in the model. These considerations would depend on immigration into the area or the existence of a "floater" population of nonbreeding individuals unable to establish territories as a result of lack of suitable habitat. Likewise, the model does not consider the quality of habitat provided by a given stand. Some marginal areas may become potential habitat depending on the size of the ovenbird population. These points must be kept in mind when interpreting simulation results.

Conclusions

The two examples of habitat simulation modelling presented have been meant as an introduction to a methodology which is not limited to either nongame bird species or the particular spatial scale with which we have dealt. In the introduction we identified two necessary components for habitat simulation: (a) the structural classification of forest stands in terms of their suitability to provide habitat for a given animal species, and (b) a forest simulator with the ability to generate the specific structural variables on which the classification is based. Neither of these components places limitations on the animal species of interest, forested system to be simulated or the spatial scale at which the habitat requirements are defined. Likewise, we have not meant the specific silvicultural practices involved in the management schemes to be presented as the most viable for the particular site modelled. Rather, we have attempted to present a methodology for predicting the effects of a wide array of both uneven and even-aged management practices on the availability of wildlife habitat on specific forested sites.

FORLOB was an example of the use of habitat simulation to integrate the creation and preservation of wildlife habitat with the concerns and need for timber production. The model was used to determine the effects of various management senarios on habitat availability for the red-cockaded woodpecker, but also the resulting timber production under these same silvicultural practices.

The long term simulations of FORHAB were meant to show that extrapolations about potential habitat cannot necessarily be made from results of a single timber cut to future cuts. Secondly, the failure to look at potential effects of repeated harvest may mislead the manager with respect to long-term habitat dynamics. For example, this was evident for a 500-year simulation of ovenbird habitat on the Walker Branch Watershed with the harvesting of timber on a 60-year rotation beginning at year 60 (Smith et al. 1981). The first cut was followed by a four-fold increase in available habitat for the ovenbird. Subsequent cuts, however, resulted in less dramatic increases and in some cases led to an elimination of potential habitat. These results show the importance of historical considerations in determining the effects of a particular timber management practice on a given forested area. The structural configuration of the forest prior to cutting is of utmost importance in the case of repeated long-term management plans. To date, this type of information has been lacking. FORHAB and models of its type can be used to provide the information on long-term management plans and combinations of management schemes before their actual implementation.

The potential applications of habitat simulation models to predict the effects of proposed management schemes on specific forested areas for both individual species and the animal community as a whole, as well as their adaptability to a diverse array of forested regions, make models such as FORLOB and FORHAB important tools for the timber-wildlife manager of the future.

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Habitat Size and Bird Community Management

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Introduction

In recent years many wildlife studies have identified structural components of a species' habitat. Management criteria are therefore suggested on the basis of habitat components showing high correlation with presence or abundance of wildlife species. Current conservation practices go beyond management for a single species, to prescribe management of communities of wildlife. To accomplish community management goals, it is necessary to apply biological principles that serve to maintain all wildlife species in each vegetation association. Concepts such as plant community succession, effects of ecotones, and theories of biogeography must be field tested and presented to wildlife managers in forms practical for managing wildlife communities.

The purpose of this paper is to review the results in the literature that show the effect of area of forest on nesting migratory bird species, and to present the results of additional field work that we have conducted in forest habitats in western Maryland. These results indicate the area sensitivity of many long distance migrants. Because 80 to 95 percent of the breeding birds in the northeastern deciduous forest are neotropical migrants (MacArthur 1959), the changes in bird species composition as a result of forest fragmentation can be immense. Management strategies based on habitat size are suggested to assist in maintaining communities of nesting migratory birds.

Biological Theory

Historically, the number of species of both animals and plants in an area has been shown to be an indicator of diversity. Arrhenius (1921) and Gleason (1922) are among the first to present this concept. Williams (1964) defines the correlation between species and areas as habitat diversity; he feels that as the sample area is increased there is a greater probability of more diversity of habitat being sampled, and so species number increases with area.

Work done by MacArthur and Wilson (1967) on bird populations of ocean islands shows that the number of species on an island increases as the island size increases. They explain that the number of species present on an island represents a balance between the immigration of new species and the extinction of species present. (See also Preston 1960, 1962.) Connor and McCoy (1979) offer another explanation for the effect of area on species numbers. They feel that species number is controlled by passive sampling from the species pool so larger areas receive effectively larger samples than smaller ones and ultimately contain more species.

Vuilleumier (1970) applied the concepts of biogeography to bird populations of the Northern Andes. He concluded that there are similarities between continental and oceanic islands. For example, both show an increase in species numbers with size. Continental island avifaunas, however, are less prone to extinction when birds are forced to move between habitat islands, because intermediate habitats provide resting areas. This land bridge idea is discussed further by Faaborg(1979).

Because of the correlations developed between area and species numbers, some biologists have suggested that larger preserves should be maintained in preference to smaller areas (Terborgh 1975, Diamond 1975, Wilson and Willis 1975). There are, however, other factors to be considered. For each habitat type there is a minimum size that must be available before most of the typical species of that habitat are likely to be present. Maintaining preserves or habitat samples larger than that particular size will increase the probability of retaining the whole complement of breeding species over a period of years, but will only minimally increase species diversity unless habitat diversity is also increased. In addition, the diversity of habitat maintained by preserving smaller preserves at some distance from each other will be greater and therefore contain more species. These ideas are discussed by Simberloff (1972), Connor and McCoy (1979), and Boyce (in press). Configuration of habitat also appears to play a role in the number of species present (Game 1980).

Habitat Size and Nesting Birds

Literature

Relationships between habitat size and numbers of bird species nesting have been investigated by a number of biologists. Forest island habitat studies, particularly in the eastern deciduous forest, have shown a strong positive correlation between forest size and numbers of breeding species of long distance migrants (Whitcomb et al. in press). Bond (1957) showed that many species of song birds were dependent on relatively large forest tracts during the breeding season.

Galli et al. (1976) studied the relationship between the number of bird species found in the breeding season in forested habitats interspersed with agricultural land in New Jersey, and found that bird species richness increased significantly as forest island size increased. Their studies included habitat islands of 24 ha (59.3 acres) or smaller because larger areas were not available. Thomas (1979) stated that bird species richness increases significantly up to about 34 ha (84 acres). His studies in the Blue Mountains of eastern Oregon did not use direct data, but were based in part on correlations developed in other studies. He felt that bird species richness could be an indicator of the richness of all vertebrate wildlife.

In 1979, Robbins published the results of a 25-year nesting season study of one small tract within a central Maryland forest. During the years of the study, the contiguous forest that had originally totaled more than 5,260 ha (12,700 acres) became progressively more fragmented (to the present 40 ha). Nine species of long-distance migrants disappeared from the breeding population of the study site, which had remained undisturbed: Broad-winged hawk, whip-poor-will, yellow-throated vireo, black-and-white warbler, worm-eating warbler, ovenbird, Louisiana waterthrush, Kentucky warbler, and hooded warbler. Furthermore, Robbins showed that data from the Breeding Bird Survey corroborates this evidence of decline of nesting long-distance migrants in the eastern deciduous forests. He examined Breeding Bird Survey data from routes conducted in central and eastern Maryland from 1974 to 1978, comparing bird counts at 500 stops with 30 different habitat characteristics. He showed a positive correlation between contiguous forest area adjacent to each stop and the number of highly migratory birds detected. This was the only factor correlated with the abundance of more than half of the 72 bird species studied. Other habitat factors that showed highly significant correlations with many different bird species were percentage of deciduous woods, percentage of coniferous woods, percentage of mixed woods, number of houses, percentage of hay fields, and presence of fences.

Whitcomb et al. (in press) computed an index of area sensitivity for a number of forest bird species by dividing the average number of territories detected at sampling points within 6-14 ha (15-35 acre) forest islands by the number detected in 80+ ha (200 acre) forest tracts. They noted a strong correlation between the area sensitivity of many bird species and their regional distribution and abundance in forest habitats. When they compared area sensitivity of each forest bird species with its biological characteristics they found that most of the species whose populations were sharply reduced by forest fragmentation have the following characteristics: (1) they are long distance migrants that winter primarily in the New World tropics; (2) they are obligate inhabitants of the forest interior; (3) they tend to nest on or near the ground; (4) they build nests in the open rather than in the protection of cavities; (5) they have comparatively small clutch sizes; and (6) most raise only a single brood of young per year. Apparently the biological needs of these forest interior specialists can be satisfied only by large tracts of undisturbed habitats despite their relatively small territories.

Area Sensitivity of Bird Species in Different Parts of the United States

Habitat correlation studies of field work done in western Maryland, Michigan, and Oregon (Anderson 1981) were examined by means of stepwise multiple regression. Results (Table 1) show that frequency of occurrence of the majority of the bird species present is highly correlated with extent of contiguous forest and distance to the edge. Further details of the Michigan and Maryland studies follow.

Michigan's Upper Peninsula

The Michigan study was conducted on the Seney National Wildlife Refuge in Schoolcraft County, Michigan, in 1976-1980 by biologists of the Migratory Bird

Table 1. Number of bird species showing correlation with forest size.

Habitat variable	Study site		
	Maryland	Michigan	Oregon
Forest size	24	18	19
Distance to edge	26	14	12
Bird species considered	36	35	26

and Habitat Research Laboratory. In this region of mixed northern forest and bog habitat, a series of wildfires burned erratically through the habitat in the mid-summer of 1976. Following the fire, 14 paired plots of 8 ha each were set up on burned and unburned areas. Data were collected on the number of breeding birds found on these plots during the summers of 1977, 1978, and 1979. Aerial photographs were used to measure the area of woodland in which each study plot was located, and to measure the distance to the nearest edge.

Western Maryland

To obtain quantitative information on area requirements of individual forest species, Robbins and Boone surveyed breeding birds in deciduous woodlots. These studies were conducted in the summer of 1979 in a 1-degree block of latitude and longitude (39°N, 77°W) that was centered in Frederick County, Maryland, and included portions of adjacent counties in Pennsylvania, Maryland, West Virginia, and Virginia. Grouping woodlots by area, the investigators located 10 or more candidate locations in each of the following size classes: 2.8-7, 8-19, 22-34, 38-120, 130-1,700, and over 4,000 ha (mainland). After excluding those woodlots that were disturbed or too narrow, those connected by corridors to other woods, those near major highways or other sources of frequent noise, and those that were predominantly coniferous or located on a floodplain, they randomly selected 20 woodlands in the 8-19 ha size and 10 in each of the other size classes.

Bird utilization of the various woodlands was compared using results from a series of point counts, a modification of the IPA (Indices Ponctuels d'Abondance) method developed by the French ornithologists, Ferry and Frochot (1970). From a marked point near the center of each of the small woodlots, or from a point randomly located in the larger ones, three 20-minute counts were made of all birds seen or heard. Each 20-minute count period was divided into four 5-minute intervals in which all birds seen or heard were recorded. Each point was sampled on 3 days during the peak of the nesting season, at different times during the early morning. Sequence of coverage on the first day was determined at random. This method proved to be well suited to the study because it permitted sampling of approximately equal areas of each of many study sites, with equal effort, spread through the peak of the nesting season.

After completion of the bird counts, a quantitative assessment of vegetation structure using a modified James-Shugart (1970) technique was made in a 0.04-ha circle at each counting point and in circles located 50 m north, east, south, and west of each counting point. When the results of the vegetation assessment were examined by discriminant analysis a 75-80 percent overlap among the structural characteristics of isolated woodlots in the various size classes was found. This indicated that differences in the bird population were probably a result of size and isolation of woodlots rather than their vegetation.

The 1979 mainland points, on the other hand, proved to be significantly different from all of the isolated woodlots in that they had greater slope and lower shrub density. Thus, their bird populations could not be compared with equal confidence to those of the various isolated woodlots. For this reason a new sample of 24 mainland counts was taken in the summer of 1980, selected from a relatively flat area of the Catoctin Mountains within the same 1-degree block. The vegetation data from the 1980 points have not yet been analyzed statistically, but a preliminary appraisal indicated that the 1980 sample was more comparable to the isolated woodlots than was the 1979 mainland sample. Therefore, bird data from the 1980 mainland plots were used in the last column of Tables 2, 3, and 4 for comparison with the 1979 counts in the smaller isolated woodlots.

In order to study the effect of woodland area, the principal avian species in the western Maryland study sites were divided into three categories. Except for the yellow-billed cuckoo, the long-distance neotropical migrants, including the flycatchers (in part), thrushes, gnatcatchers, vireos, warblers, and tanagers (Table 2), were found least frequently in the smallest woodlots and most frequently in the continuous forest. Only 5 of the 17 species were found in the 2.8-7 ha woodlots. Discounting irregularities that are probably largely attributable to small sample size, frequency of occurrence in Table 2 appears to increase as woodlot size increases. On the other hand, the short-distance migrants in Table 3 show the opposite trend; these typically "edge" species were found with decreasing frequency as woodlot size increased. The permanent residents in Table 4 do not show a consistent trend in either direction; except for the large pileated woodpecker, which was scarce or absent in the three smallest size classes, all species were found in good numbers in isolated woodlots of all sizes.

Clearly, neotropical migrants were adversely affected as woodlot size decreased. Because these birds make up the great majority of the breeding population in undisturbed eastern deciduous forest, there is a special urgency to keep their needs in mind when planning forest management. Robbins (1980) has made preliminary estimates of the critical size of deciduous forest habitat that is required to support viable populations of various forest-interior species. Additional work along this line involves refinement of initial estimates and expansion of field work into other habitats and geographic areas.

Management Implications

All the data we have collected to date indicate that many nesting migratory bird species, particularly long-distance migrants, are sensitive to habitat size. Species in the eastern deciduous forests are particularly affected because of the large number of neotropical migrants nesting there. Each major community appears to have a minimum size below which area sensitive species disappear.

Habitat configuration may be another important concept in the context of bird community management. Smaller tracts of land, for example, can often be used effectively in management practices when connected to larger tracts of land by means of wooded corridors (Robbins 1979).

Some habitats, such as riparian zones in arid environments, are very important for birds (Tubbs 1980). Size of these areas is critical to maintain the diversity of birds.

Effective management of bird communities means effective management of forest lands in tracts large enough so that different successional stages can occur. Management practices such as logging, thinning, brush control and reforestation can often be rotated among different parts of the management area, maintaining enough undisturbed forestland to support area-sensitive bird species. Grazing in the West can also be accomplished on a rotational basis on large tracts of the land, leaving some areas undisturbed each year to allow migrant species to nest.

Table 2. Frequency of detection (%) of neotropical migrants in deciduous woodlands of various sizes in western Maryland.

Woodlot area	ha (acres)	2.8-7 (7-17)	8-19 (19-47)	22-34 (56-84)	38-120 (94-293)	130-1,700 (320-4,200)	4,000+ (10,000+)
No. of sample points		10	19	11	8	10	24
Yellow-billed cuckoo		100	84	82	75	90	58
Acadian flycatcher		0	21	36	75	40	54
Eastern wood pewee		50	95	82	100	100	100
Wood thrush		70	95	100	100	100	67
Blue-gray gnatcatcher		0	5	27	25	20	46
Yellow-throated vireo		0	0	0	0	0	21
Red-eyed vireo		10	68	100	88	90	100
Black-and-white warbler		0	0	0	0	0	29
Worm-eating warbler		0	0	18	13	20	17
Cerulean warbler		0	0	0	0	0	24
Ovenbird		0	0	27	25	70	100
Kentucky warbler		0	26	18	50	60	21
Hooded warbler		0	0	0	0	0	42
American redstart		0	0	0	0	0	25
Scarlet tanager		30	68	82	100	90	100
Mean		17.3	30.8	38.1	43.4	45.3	53.6

Table 3. Frequency of detection (%) of short-distance migrants in deciduous woodlands of various sizes in western Maryland.

Woodlot area	ha (acres)	2.8-7 (7-17)	8-19 (19-47)	22-34 (56-84)	38-120 (94-293)	130-1,700 (320-4,200)	4,000+ (10,000+)
No. of sample points		10	19	11	8	10	24
Yellow-shafted flicker		100	95	82	63	40	4
Great crested flycatcher		100	95	73	88	80	37
Blue jay		100	95	100	100	100	79
Gray catbird		70	63	36	25	20	8
Common grackle		100	100	91	88	70	21
Brown-headed cowbird		60	68	36	100	80	37
Rufous-sided towhee		60	58	36	45	60	58
Mean		84.3	82.0	64.9	72.7	64.3	34.9

Table 4. Frequency of detection (%) of permanent residents in deciduous woodlands of various sizes in western Maryland.

Woodlot area	ha (acres)	2.8-7 (7-17)	8-19 (19-47)	22-34 (56-84)	38-120 (95-293)	30-1,700 (320-4,200)	4,000+ (10,000+)
No. of sample points		10	19	11	8	10	24
Pileated woodpecker		0	11	18	63	70	46
Red-bellied woodpecker		90	100	91	100	100	37
Hairy woodpecker		20	37	55	25	60	8
Downy woodpecker		70	89	73	88	90	58
Carolina chickadee		30	89	82	88	50	25
Tufted titmouse		80	100	100	100	100	58
White-breasted nuthatch		50	68	91	88	80	37
Cardinal		90	95	100	100	100	21
Mean		53.8	73.6	76.3	81.5	81.3	36.3

What size of habitat is needed to maintain adequate populations of area-sensitive species? Thomas (1979) feels that 34 ha (84 acres) are sufficient in the Blue Mountains of Oregon. The western Maryland data (Table 2), however, indicate that even 100 to 1,300 ha is too small to support the full complement of forest interior species in eastern deciduous forests.

Habitat configuration, distance to disturbance such as roadways and transmission lines, wooded corridors, and management practices all play a role in maintaining breeding bird communities, and complicate the task of the researcher who is attempting to define minimal area needs. The manager must not only (1) have access to information on the minimum size that can support a breeding bird community in the type of habitat under management; but also (2) maintain a diversity of habitats so that the minimum area of each successional sere is always available to breeding birds in that region; and (3) where possible, maintain or create corridors to connect small plots with larger ones.

Acknowledgements

We express our appreciation to our colleagues, D. D. Boone, D. K. Dawson, B. A. Dowell, D. B. Inkley, P. G. Kalka, J. R. Partelow, P. K. Stoddard, and M. Walch, who participated in the field work, and to D. D. Boone, D. K. Dawson, and J. R. Partelow, who contributed importantly to the data analysis and made helpful comments regarding the manuscript. D. L. Anderson, D. B. Inkley and D. E. Runde also reviewed the manuscript.

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Appendix. Scientific names of birds

Broad-winged hawk	*Buteo platypterus*
Yellow-billed cuckoo	*Coccyzus americanus*
Whip-poor-will	*Caprimulgus vociferus*
Yellow-shafted flicker	*Colaptes auratus*
Pileated woodpecker	*Dryocopus pileatus*
Red-bellied woodpecker	*Melanerpes carolinus*
Hairy woodpecker	*Picoides villosus*
Downy woodpecker	*Picoides pubescens*
Great crested flycatcher	*Myiarchus crinitus*
Acadian flycatcher	*Empidonax virescens*
Eastern wood pewee	*Contopus virens*
Blue jay	*Cyanocitta cristata*
Carolina chickadee	*Parus carolinensis*
Tufted titmouse	*Parus bicolor*
White-breasted nuthatch	*Sitta carolinensis*
Gray catbird	*Dumetella carolinensis*
Wood thrush	*Hylocichla mustelina*
Blue-gray gnatcatcher	*Polioptila caerulea*
Yellow-throated vireo	*Vireo flavifrons*
Red-eyed vireo	*Vireo olivaceus*
Black-and-white warbler	*Mniotilta varia*
Worm-eating warbler	*Helmitheros vermivorus*
Cerulean warbler	*Dendroica cerulea*
Ovenbird	*Seiurus aurocapillus*
Louisiana waterthrush	*Seiurus motacilla*
Kentucky warbler	*Oporornis formosus*
Hooded warbler	*Wilsonia citrina*
American redstart	*Setophaga ruticilla*

Common grackle	*Quiscalus quiscula*
Brown-headed cowbird	*Molothrus ater*
Scarlet tanager	*Piranga olivacea*
Cardinal	*Cardinalis cardinalis*
Rufous-sided towhee	*Pipilo erythrophthalmus*

Forest Management and Anadromous Fish Habitat Productivity

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Introduction

In 1976, the USDA Forest Service established a research program to study the biological, physical, and economic aspects of anadromous salmonid habitat. The Anadromous Fish Habitat Research Program is a cooperative effort involving scientists at three USDA Forest Service forest and range research stations: the Pacific Northwest at Portland, Oregon; the Intermountain at Ogden, Utah; and the Pacific Southwest at Berkeley, California.

Scientists at these facilities are studying the relationship between forest management practices and the habitat of anadromous salmonids to develop better ways to achieve concurrent production of timber, fish, minerals, livestock, and other resources. The program is oriented around three types of studies: (1) habitat requirements, (2) effects of various land uses on habitat, and (3) development of ways to improve fish habitat.

The anadromous fishery resources of western North America are produced largely within forested watersheds. Eight species of anadromous salmonids including five salmon—chinook *(Oncorhynchus tshawytscha),* coho *(O. kisutch),* sockeye *(O. nerka),* chum *(O. keta),* and pink *(O. gorbuscha);* two trout—steelhead rainbow *(Salmo gairdneri)* and coastal cutthroat *(S. clarki);* and one char—Dolly Varden *(Salvelinus malma),* inhabit waters of the Pacific Northwest and Alaska. Habitat requirements of the fish are specific, and alterations of habitat by humans affects production in many ways.

Forest and rangeland management activities that can influence the quality of anadromous fish habitat include timber harvest, road construction, livestock grazing, mining, water developments of various kinds, and recreational pursuits. This paper discusses some of the specific interrelationships between fish habitat and timber harvest, road construction, and livestock grazing. These three activities were selected for discussion because the USDA Forest Service is actively engaged in studies pertaining to these areas of concern.

More specifically the following subjects will be discussed: (1) effects of organic debris and its removal on fish habitat; (2) effects of mass soil movements on fish habitat; and (3) preliminary results of studies concerned with the relationship between different livestock grazing systems and fish habitat.

Organic Debris

Organic debris from forested watersheds of the Pacific Northwest and Alaska enters streams through direct litterfall, various lateral movements including landslides, debris torrents, timber felling, and streambank erosion, plus blowdown of trees, treetops, and branches. Natural accumulation of debris in streams is slow and fairly constant in mature forests, and eventually moves toward an equilibrium between the rate of increase and rate of biological and physical processing in old-growth forests (Sedell and Triska 1977). Logging, or change in forest succession due to natural events can shift the equilibrium causing significant changes in streams and fish populations.

Organic debris can be divided into two categories based on size of individual pieces. Large debris consists of tree boles, rootwads, and large limbs, while small debris is composed of needles, leaves, twigs, and branches. The two categories of debris affect the physical characteristics of streams and production of anadromous fish in different ways.

The effects of organic debris on fish production can be either beneficial or detrimental. The effect is often determined by the size of the recipient stream, the size, quantity, and accumulation rate of woody debris entering the channel, and species of fish. Small streams in the Pacific Northwest are strongly influenced by adjacent terrestrial environments and are dependent largely upon external energy inputs, thus tend to be extrinsic and heterotrophic. The following discussion pertains primarily to small streams—first to third order (Strahler 1957)—which are important producers of anadromous salmonids, and yet because of their size are readily influenced by organic debris.

Several major positive effects of organic debris have been identified in previous studies. Large debris creates physical habitat diversity for rearing salmonids (Swanson and Lienkaemper 1978), provides hiding and resting cover in summer (Baker 1979), respites from floods and ice in winter (Bustard and Narver 1975), and stabilizes streambeds and banks (Swanson and Lienkaemper 1978). It also slows downstream movement of inorganic sediments and fine organic matter (Swanson and Lienkaemper 1975), thus providing an energy base for the aquatic food chain and retaining gravels essential for salmonid reproduction and production of fishfood organisms. On the other hand, massive accumulations of large debris can create barriers to migration of anadromous fish (Holman and Evans 1964), cause bank erosion and channel instability during flood events (Helmers 1966), and debris jams when dislodged by high flows can scour streambeds, thereby removing cover and gravel and altering stream morphology. Small debris provides the primary source of energy for the aquatic food chain in small forested streams (Cummins 1974), but excesses of small debris sometimes cause ponding and depletion of dissolved oxygen in stream waters (Hall and Lantz 1969). Small debris that infiltrates stream gravels can also cause the depletion of intragravel dissolved oxygen (Hall and Lantz 1969) and mortality of incubating salmonid embryos. Accumulations of fine organic material can also produce potentially toxic leachates, particularly in estuaries (Buchanan et al. 1976).

Bryant (1980) measured the evolution of large organic debris after timber harvest in the Maybeso Creek watershed in southeast Alaska. He found a decrease in accumulations of large debris 15 to 20 years after logging, resulting in a decrease in pool areas and an increase in riffles. Although amount of debris decreased in general, remaining debris along the banks and projecting into the channel still influenced channel morphometry, and in some instances contributed to streambank stability. This residual debris helped to maintain pools that were important rearing areas for juvenile salmonids.

Removal of debris has been a concern of resource managers for many years. When should debris be removed and when should it be retained? Often all logging-associated debris has been removed, including large material. In southeast Alaska, natural debris accumulates very slowly (Swanson et al. 1977), and total debris removal often results in a completely open channel (Bryant unpublished). Effects of total debris removal on aquatic invertebrates and Dolly Varden populations were assessed by Elliott (1976). He found a shift in the invertebrate community structure in Starrigaven Creek near Sitka, Alaska, to taxa associated with riffles within a year after debris removal. Dolly Varden populations also exhibited an 80-percent reduction.

Differences between natural and logging debris were also apparent in recent studies in southeast Alaska (Bryant unpublished). Natural debris was often partially decomposed and less concentrated than logging debris. Logging debris was smaller, contained more floatable material, and occurred in more dense and patchy concentrations. Streambed scour and channel instability resulted more from logging debris than from natural debris.

The effects of organic debris may depend on the species of anadromous salmonids present (Narver 1971). Debris that forms pools used by rearing coho salmon may promote sediment deposition in riffles used by pink salmon for spawning. Conversely, removal of debris accumulations may reduce pools and increase riffles, providing less productive rearing areas, but more spawning areas.

Mass Soil Movements

Mass erosion events are a common occurrence in forested steeplands of western North America. Landslides, slump earthflows, and debris torrents account for most mass erosion in the Pacific Northwest but debris torrents are the most universally distributed and frequent events. The rate at which debris torrents occur in steep unstable watersheds is closely linked to timber management and the presence of roads (Swanson and Dyrness 1975). Since anadromous fish and timber are concurrent crops in most western watersheds, it is important to understand how debris torrents affect fish production and harvest.

Debris avalanches, the precursors of debris torrents, are often initiated when intense precipitation saturates exposed soils in road cuts and fills, or clearcuts. The saturated soil slumps under its own weight and forms a slurry which moves rapidly downslope, entraining additional soil, rock, and woody debris. Before losing momentum, most torrents enter the channels of small streams. Once in streams, the soil, rock, and debris might move downstream, scour the channel to bedrock, or be deposited in a massive dam of organic and inorganic debris. In either case, the physical features of the stream channel are changed and fish habitat is altered.

In 1978 we initiated a study to assess the relationships between debris torrents and habitat of anadromous salmonids. The study was designed to: (1) quantify site-specific effects on salmonid habitat immediately below the egress of a debris torrent and assess longevity of those effects, and (2) determine the long-term relationships between debris torrents and fish habitat within an extended reach of stream. The first objective was accomplished with an extensive study of four debris torrents in different watersheds, and the second with an intensive study in a single watershed.

Site-Specific Effects—Extensive Evaluation

Torrents on four streams in the Oregon Coast Ranges about 50 miles (80 km) west of Eugene were studied from 1978 through 1980. Two of the streams (Hadsall Creek and Knowles Creek) were small at the study sites, flowing less than 0.5 cubic feet per second (cfs) (14 liters/sec.) in summer, and two were larger (Tenmile Creek and Cummins Creek), flowing more than 2.5 cfs (71 liters/sec.) in summer. The smaller streams received large inputs of debris (greater than 1,000 cubic yards (765 m^3)) while the larger streams received smaller amounts (less than 500 cubic yards (380 m^3)). The torrents on Hadsall and Knowles creeks occurred in February 1978, and those on Cummins and Tenmile creeks date from November 1975. The study was designed to assess both spatial and temporal habitat changes caused by debris torrents. Spatial effects were assessed by sampling similar stream habitats above and below a torrent egress (point where torrent exited first order stream and entered second or third order stream) at low summer streamflow and comparing results. Consistent major differences were assumed to be attributable to the effects of debris torrents. Samples collected at given locations over a period of years will also be compared to assess recovery rates.

The major parameters examined included:
1. structure and biomass of fish populations,
2. numbers, biomass, and size of aquatic invertebrates,
3. textural composition of spawning gravels,
4. surface and intragravel dissolved oxygen, and
5. instream cover.

Fish populations examined included cutthroat trout, juvenile steelhead trout, juvenile coho salmon, and freshwater sculpins *(Cottus perplexus* and *C. gulosus).* Numbers and biomass of all species of fish were reduced in all sampling areas impacted by debris torrents (Table 1). Biomass of salmonids was reduced an average of 90 percent in the small streams and 55 percent in the larger streams. Populations of sculpins suffered similar reductions. In three years of sampling, no definite trends toward recovery were noted.

The effects on aquatic invertebrates were variable. Biomass of benthic macroinvertebrates longer than 0.39 inches (1 mm) was lower in square-foot bottom samples collected in torrent-disturbed areas in three of the four streams sampled, but no definite trends in numbers or mean lengths of individual organisms were noted. The largest reduction of benthic invertebrates was observed on the smallest stream, Hadsall Creek.

Texture of spawning gravels and supply of intragravel dissolved oxygen are critical factors in survival of incubating salmonid embryos. Fine sediments less than 0.39-inch (<1-mm) diameter and low concentrations of intragravel dissolved oxygen tend to reduce reproductive success of salmonids. We noted an initial increase in fine sediments of more than 90 percent by weight in torrent-disturbed gravels of Hadsall Creek, and little improvement occurred during two years of sampling (Table 2). Knowles Creek had no upstream gravels near the torrent egress so comparative data for that stream are lacking. No major changes were observed in gravels of the larger streams. Intragravel dissolved oxygen followed a similar pattern, dropping substantially in the disturbed area of Hadsall Creek where sand and organic debris were entrained in gravels, but changing little on the larger streams (Table 2).

Table 1. Biomass of fish in stream habitat above and below a debris torrent egress.

Stream	Species	Biomass, pounds per acre (g per m2)					
		1978		1979		1980	
		Above	Below	Above	Below	Above	Below
Hadsall	Cutthroat	42.97(4.82)	7.93(0.89)	48.85(5.48)	dry	intermittent	dry
Creek	Sculpins	32.36(3.63)	0.36(0.04)	47.24(5.30)	dry	intermittent	dry
Knowles	Coho	4.10(0.46)	2.85(0.32)	4.01(0.45)	0.80(0.09)	dry	5.17(0.58)
Creek	Sculpins	11.86(1.33)	6.86(0.77)	10.70(1.20)	8.65(0.97)	dry	14.00(1.57)
Cummins	Steelhead	9.81(1.10)	3.39(0.38)	31.02(3.48)	6.51(0.73)	21.48(2.41)	4.10(0.46)
Creek	Sculpins	13.28(1.49)	8.74(0.98)	33.42(3.75)	16.58(1.86)	16.40(1.84)	16.31(1.81)
Tenmile	Steelhead	11.32(1.27)	5.61(0.63)	16.76(1.88)	2.94(0.33)	16.49(1.85)	12.75(1.43)
Creek	Sculpins	77.55(8.70)	29.24(3.28)	47.51(5.33)	19.52(2.19)	51.35(5.76)	30.49(3.42)

Table 2. Percent weight fine sediment less than .039-inch (<1 mm) diameter and intragravel dissolved oxygen (mg/1) in salmonid spawning areas above and below a debris torrent egress.

		1978		1979		1980	
Stream	Parameter	Above	Below	Above	Below	Above	Below
Hadsall	Sediment	12.06	23.33	17.16	23.56	—	—
Creek	Oxygen	9.3	6.7	6.5	4.4	6.5	dry
Cummins	Sediment	8.99	6.31	6.73	8.67	—	—
Creek	Oxygen	10.3	8.3	10.7	11.0	8.3	6.1
Tenmile	Sediment	7.26	7.14	8.93	8.54	—	—
Creek	Oxygen	10.0	7.3	10.3	11.7	8.0	6.3

Instream cover was also examined in disturbed and undisturbed areas in the stream channels of Hadsall and Tenmile creeks. The largest changes in cover were observed for the small stream. The torrent scoured most instream cover from the channel of Hadsall Creek below the egress and filled most pools with sediment. Both cover and pool area were reduced by about 70 percent. Pool area on Tenmile Creek was unchanged by the debris torrent, but cover in the form of woody debris increased about 30 percent in the disturbed area.

In summary, the site-specific effect of debris torrents on fish habitat and production was generally negative in the area immediately below the torrent egress. The cumulative effects were greatest on small streams that received large quantities of debris.

Extended Reach Effects—Intensive Evaluation

The effects of debris torrents on habitat and production of anadromous fish were also studied on a 1-mile (1.6-km) reach of Knowles Creek in 1979 and 1980. Observations were also made outside the 1-mile (1.6-km) reference reach. Bedrock in the Knowles Creek watershed is sandstone, and about 80 percent of the stream substrate along the main-stream is composed of sandstone bedrock. In this sediment-poor system, fish habitat diversity in terms of cover, pools, and variations in substrate in the study reach was directly related to organic and inorganic materials deposited in the channel by debris torrents. Habitat utilization by adult and juvenile coho salmon was also strongly associated with habitat changes resulting from debris torrents.

Debris torrents entering first- through third-order stream channels of Knowles Creek appear to have consistent and predictable effects on habitat of anadromous fish. Recent torrents on this stream occurred during intense storm events when all streams in the basin were at or near flood stage. Typically a large mass ($>$1,000 yd^3(765 m^3)) of large woody debris, rock, and soil entered the stream from a steep side channel. High flows tended to float the woody material out of the system, or deposit it at the stream margins or in a massive debris jam somewhere downstream. Large rock, rubble, and soil in the torrent created a dam in the channel, changed the channel gradient, and created a small lake upstream. Sediment transported by subsequent winter freshets was deposited at the head of the lake, forming new gravel bars. Over a period of years the lakes fill with gravel.

There is evidence of three large debris torrents in the 1-mile study reach of Knowles Creek. Two are recent—one occurred on November 14, 1980, and the other in February 1977. The third is an old torrent of unknown age. Gradient changes caused by the 1977 torrent and the undated torrent were similar. The stream channel rises at 0.8 percent grade in the area of both torrents. A stable dam of boulders and rubble increased the gradient at the egress of the 1977 torrent to 1.6 percent for a distance of 450 feet (137 m), and gradient at the undated torrent was increased to 1.9 percent for 600 feet (183 m). Gradient changes caused by the 1980 torrent have not yet been surveyed. None of the debris dams retarded upstream passage of anadromous salmonids. The 1977 and 1980 torrents created lakes with volumes of 1.7 and 1.8 acre feet (2,097 and 2,220 m^3), respectively. The capacity of the debris torrent ponds for rearing underyearling coho salmon exceeded other habitats available in the stream. The population of coho rearing during the summer in the pond created by the 1977 torrent was estimated at 875 fish in 1979 and 965 in 1980, or an average of about 1.77 fish per lineal foot (5.8 fish per lineal meter) of stream channel. Coho population estimates from four unponded segments of Knowles Creek indicated an average of 0.18 coho per lineal foot (0.6 per m) in summer. In 1979 and 1980, the debris torrent pond was rearing underyearling coho at a rate nearly 10 times greater than the unponded channel. The number of coho rearing in the 530-foot-long (160-m) pond was estimated to be approximately equal to the number rearing in 1 mile (1600 m) of unponded habitat.

The debris torrent ponds also provided habitat for adult coho. Ponds created by the torrents provided resting habitat for adult coho awaiting spawning. Ponds also provided natural settling basins for gravels transported downstream during freshets. Observations made during the winter of 1980 illustrate the importance of torrent ponds to adult coho. On December 13, 1980, 92 adult coho salmon were observed in the 1-mile (1.6-km) study reach of Knowles Creek. Eighty-five percent of the fish were either resting in the deep ponds created by the 1977 and 1980 torrents, or spawning on gravels impounded by the three torrents. Ten coho redds were counted in the reach and 7 were in gravels impounded by torrent-produced dams.

Coho make immediate use of habitat created by debris torrents. The 1980 torrent was less than three weeks old when 14 adults were seen resting in the new pond and 2 redds were observed on 25 yd^2 (21 m^2) of freshly impounded gravel at the head of the pond.

Our study of an extended reach of stream on Knowles Creek has helped clarify the effects of debris torrents on fish habitat in that watershed. Although torrents have a negative effect on habitat in areas inundated with organic and inorganic debris, the over-all effect on Knowles Creek appears positive. Within the extended reach, debris torrents enhanced spawning and rearing habitat for adult and juvenile coho salmon and did not interfere with adult migration routes.

The results obtained on Knowles Creek might be generally characteristic of other sediment-poor systems in the Coast Range sandstone formation. Similar changes in habitat probably do not occur in sediment-rich systems where sediment added by torrents would add little to habitat diversity and torrent-created ponds would fill rapidly with sediment. Additional research is needed to determine how broadly results from Knowles Creek can be inferred.

Future research is also needed to determine how the accelerated occurrence of debris torrents caused by timber management affects fish habitat. The rate of accumulation of debris in stream channels could be the determining factor in whether cumulative effects on habitat of anadromous salmonids are positive or negative.

Livestock Grazing Systems

Livestock use streamside areas heavily, for feeding and resting. The stream itself is often their only source of water; this also promotes use of streamside areas. Many studies have described the adverse impacts of overgrazing and concentration of livestock along streams, but these have usually dealt with physical impacts such as soil compaction, streambank trampling, and reduction of streamside vegetation (Meehan and Platts 1978). A few studies have compared biomass of salmonids in stream reaches protected from streamside grazing with reaches along which grazing occurred. Gunderson (1968) showed that brown trout (*Salmo trutta* Linnaeus) production was considerably greater in sections of Rock Creek, Montana, adjacent to ungrazed areas than in sections adjacent to grazed areas. These findings were later verified by Marcuson (1971). Platts and Rountree (1972) reported fish habitat was damaged, primarily from bank trampling, more along sections of Bear Valley Creek, Idaho, than along ungrazed sections.

Several different livestock grazing systems are in use today (Meehan and Platts 1978). These systems differ primarily in the intensity of use within various pastures of a grazing allotment. All pastures may be grazed continuously throughout the grazing season; a given pasture may be grazed during the early part of the season and left ungrazed during the latter part, or vice versa; various pastures may be rested periodically for a full grazing season; or any number of combinations or modifications of these strategies may be used.

The USDA Forest Service Anadromous Fish Habitat Program has two studies underway to evaluate the effects of various grazing systems on fish habitat. One of the studies is being conducted on several streams in central Idaho; the other is on Meadow Creek in northeastern Oregon's Blue Mountains. Neither study has been completed, so conclusive results cannot be reported at this time. We have been working on the Meadow Creek study, and will briefly discuss this study and some preliminary observations.

The stream was divided into four 1.25-mile (2.0-km) sections to study effects of various livestock grazing systems, with and without wildlife (deer and elk) influence, with a separate 1.25-mile upstream "control" section. The fisheries portion of the study concentrated on the upstream treatment section. This section was subdivided into five units. The first year, cattle grazed season-long in the unit farthest downstream, while upstream units remained ungrazed. The second year, the two downstream units were grazed, etc., so that at the end of the five-year study, the most downstream unit had been grazed for five years, the next upstream unit for four years, etc. with the farthest upstream unit being grazed for one year. Stream channel and bank profiles, benthic and invertebrate drift samples, and steelhead trout population estimates and stomach contents were obtained before cattle were put on, at mid-season, and after cattle were removed each year. Water temperature and various chemical parameters were measured as well.

Data analysis will continue for about two more years. Presently, nothing can be said about effects of grazing on invertebrate organisms. Preliminary observations show no obvious differences between fish standing crops in the control section and the treatment sections after three years of season-long grazing. Stream channel changes have not yet been fully analyzed, but preliminary examinations indicate changes are due more to flow conditions than to direct livestock effects.

The primary purpose of this discussion has been to outline the general scope of the grazing study and the kinds of data that will result.

Summary

The USDA Forest Service Anadromous Fish Habitat Research Program is investigating relationships between forest and rangeland management and fish habitat productivity. Scientists are studying habitat requirements of anadromous salmo-

nids, the effects of various land uses on habitat, and habitat enhancement techniques. Current research is clarifying the impact of large woody debris, mass soil movements, and livestock grazing systems on habitat productivity for anadromous salmonids.

Large woody debris can create habitat for rearing salmonids, but may cause sedimentation in spawning areas. Large, naturally occurring debris can promote streambank stability and reduce streambed scour. Large accumulations of fine organic debris can adversely affect salmonid habitat by reducing dissolved oxygen and producing toxic leachates. In some instances, large debris accumulations may impede fish movement. Total removal of debris can result in a completely open channel, promoting streambed scour, streambank instability, and loss of fish habitat productivity.

Debris torrents, a common mass erosion event in the Pacific Northwest, have a negative impact on habitat and production of anadromous salmonids in small streams immediately downstream from the torrent egress. In a restricted area, both spawning and rearing habitat are degraded and fish production is reduced. Studies within a 1-mile (1.6-km) reach of Knowles Creek, however, indicate that the total effect of debris torrents in that sediment-poor watershed tends to be positive. Torrents created habitat diversity by adding boulders, rubble, gravel, and woody debris to the channel and increased both quantity and quality of habitat for juvenile and adult coho salmon. Torrents are a natural physical process that provide woody debris and gravel necessary to maintain productive fish habitat. The rate at which debris torrents occur might be the most important factor in determining whether cumulative effects are positive or negative:

Very preliminary results of our livestock grazing study do not show profound effects on fish populations among various grazing systems or between one to three years of season-long grazing and ungrazed controls. Final analysis of results should be completed in 1982.

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Wildlife–Forest Relationships: Is a Reevaluation of Old Growth Necessary?

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Introduction

Early in the establishment of wildlife management as a profession, theories were commonly presented as facts. It is not surprising then, that subsequently we have often been confused with contradictory evidence. One example is the aphorism that good timber management is good wildlife management. Bunnell (1976:147) protested that advocates of this doctrine espoused it "on the basis of ingenuous faith in the term 'good' with little supportive data."

This principle apparently was not based on experience with timber *management* practices that resulted in "good" things for wildlife, but, instead, on the undocumented belief that higher populations of some game species in certain areas occurred after industrial-scale logging and/or widespread wildfire had removed much of the virgin forest. A corollary, therefore, was that "old-growth" forest was relatively unproductive of wildlife (as stated by many authors including, for example, Leopold 1949, 1950, Cowan 1956, Severinghaus and Cheatum 1956, Robinson 1958, and Jenkins and Bartlett 1959). Therefrom, it seems to have been concluded that any means used to eradicate "old-growth" would yield the nebulous "good for wildlife."

Recently, Thomas (1979:11) citing Bunnell (1976) warned "it has become increasingly obvious that such cliches . . . will no longer suffice." We agree, but should concede our doubts were not quickened until we were assigned to study the influences of timber harvesting and management on wildlife habitat in southeast Alaska where there is a unique opportunity to contrast truly pristine forest with logged areas in various stages of succession. Early in the program we acquired data (discussed later) that did not fit the theory. One possibility, of course, was that the Alaskan forests were somehow different from other North American forests. Consequently, we searched the literature for information on those earlier forests and the data that lay behind the doctrine.

The Historical Record

Harvesting the "Old-growth" Forests

The extent of "old-growth" forest today is much different than when European settlers first colonized this continent over 300 years ago. According to rough estimates the original forests of commercial quality equalled about 850 million acres (344 million ha) with about 75 percent of this area occurring east of the Great Plains (Clawson 1979, Kellogg 1907). Much of today's commercial forest land, about 500 million acres (202 million ha) (Clawson 1979), is in second or third generation timber stands. Although it is difficult to accurately trace the demise of "old growth" because of limited, inaccurate, and noncomparable data, several sources allow us to describe this history generally.

Following early colonization on the Eastern Seaboard, trees were harvested for firewood, lumber, and to clear the land for agriculture (Brown 1948). In the early 1800s, wood was in demand in the Northeast for fuel, charcoal, and shipbuilding. By the mid 1800s, lumbering was developing rapidly and expanding to the west and south from New England (Reynolds and Pierson 1923, Brown 1948), reaching its peak about 1900 (Clawson 1979). The progression of the timbering industry in the United States through the nineteenth century was described by Reynolds and Pierson (1923:11) as follows:

> For 100 years the lumber industry has been in the process of migration from one forested region to another. . . . As the first cut of pine in the more thickly settled coast regions drew near its end, the exploitation of the white pine forests of the Lake States began and the hardwood regions of the central Appalachians were opened to the market. As the cut of the Lake States drew to its close many lumber manufacturers of that region removed their operations to the South and began the attack upon the great belt of long-leaf pine stretching from Virginia to Texas. . . . Now [1920] four-fifths of the original southern pine is gone, and there is in progress a marked drift of lumbermen from the Southern States to the Pacific Coast, and to the northern part of the Rocky Mountains, known as the Inland Empire.

Reynolds and Pierson (1923) reported that by 1920, 96 percent of the virgin timber had been cut from the Northeast and Central States, 90 percent from the Lake States, and the South was not far behind. They reported that 61 percent of the total remaining sawtimber was west of the Great Plains. In the West, as of 1920, 17 percent of the timber had been cut and this was from the best and most accessible stands (Reynolds and Pierson 1923). These authors further stated that even Colorado, Utah, and Wyoming were well past the peak of their production. By 1920, Reynolds and Pierson (1923:21) stated, "we are beginning in earnest to cut our last reserve of virgin timber. . . . "

As of 1938, the Society of American Foresters (1947) classified 22 percent of the total forest area (about 460 million acres [186 million ha]) of the United States as "old growth." "Old growth" was defined here as "original forest"; however, portions of the so-called "old growth" were described as having been culled. East of the Great Plains, the forest was largely cut over with remnants of "old growth" representing about 11 percent of the commercial forest land (Society of American Foresters 1947).

In 1953, "old growth" (which in this report was not defined) represented only 10 percent of the commercial forest land (USDA Forest Service 1958). Thirty-three percent and 10 percent of this limited "old growth" was in the Pacific Northwest and Alaska, respectively, and no significant old-growth acreage remained in the Eastern forest area.

In 1963, "old growth" was defined as being trees past rotation age (USDA Forest Service 1965:225). To our knowledge, "old growth" has subsequently been poorly defined or its occurrence has been unreported in nationwide inventories. We know that some "old-growth" stands exist in the Eastern deciduous forests but these are scattered, of small size, and rare (Bormann and Likens 1979, Lorimer 1980). The major states where significant "old growth" still exists today are Washington, Oregon, Idaho, Montana, California, and Alaska. According to Juday (1978:498), in the Pacific Northwest, "The elimination of old growth on forest industry lands is now virtually complete." There, most of the remaining "old growth" occurs primarily on public lands in remote areas and higher elevations. Vast tracts of unbroken "old growth" occur today only in Alaska. All of the timber harvest in Alaska today is in "old growth," and, following the historical pattern of logging in other regions of the country, the present harvest is concentrated in lower elevation stands of highest quality and volume.

Deer Populations in North America

Within the limitations of these proceedings, we can only present a cursory review of some of the historical accounts that are relevant to the topic. We have selected deer (*Odocoileus* spp.), because their history in North America is well documented, probably due to their high market and sporting value.

The numerous anecdotal records reviewed by Young (1956) in *The Deer of North America* suggest that before the virgin forests of this continent were significantly altered by man, deer apparently were very abundant: Ernest Thompson Seton "estimated" the original North American deer population at more than 50 million animals; between 1755 and 1773, over two and one-half million pounds (1.13 million kg) of deerskins from about 600 thousand deer were shipped to England from Savannah, Georgia; in 1753, 30 thousand deerskins were shipped from North Carolina; in 1786, Quebec exported 132,271 deerskins.

Schemnitz (1973:12) said, "Historical accounts in the Northeast reveal an abundance of wildlife in the period 1605–1820 (Banasiak 1961). . . . In the period between 1820–1880, logging, agriculture and livestock grazing increased. Commercial hunting was prevalent. Deer populations declined greatly (Silver 1957).' '

In the Lake States, heavy market hunting of deer began about 1860, and enormous quantities of venison were shipped by rail to the Milwaukee and Chicago markets (Bersing 1956:10). In Michigan (Jenkins and Bartlett 1959:11), "an average hunter could take 10 or 15 animals a day. . . . and in 1878 . . . 70,000 carcasses [were] shipped out of the Lower Peninsula. In 1880, rail stations handled 100,000 deer.' ' By the end of the century, both timber and deer were nearly gone from the Lake States (Bersing 1956, Jenkins and Barlett 1959).

In the Gulf South, according to Davis (1945:92-94), "The sale of deer hides was an important item of trade before 1900. . . . " Impressed with this volume of trade, Strecker (1927:108) said, "This animal [white-tailed deer] must have been excessively abundant before the country was settled by whites." Logging activity peaked in this region around 1910 (Maxwell 1973). Subsequently, the deer population declined radically as wanton hunting—and logging—continued, and reached a low point in eastern Texas (the timber country) about 1930 (Davis 1945).

In the Northeast and the Lake States, as in Texas, the fantastic market harvests of deer occurred *during* the logging era. Concern over declining deer populations led to strict hunting regulations. In Michigan (Jenkins and Bartlett 1959:13), "we were scraping the bottom of the deer barrel between 1900 and 1910"; in Wisconsin (Bersing 1956:15), "probably the population reached the lowest point before World War I."

If we are to believe more recent studies on post-logging habitat conditions (Leopold 1949, Verme 1965, Wallmo et al. 1976, Blymeyer and Mosby 1977, Wallmo and Schoen 1981), deer populations declined radically *exactly* when they should have increased, *if* removal of the "old-growth" forest had resulted in its supposed influence. DeGarmo and Gill (1958:2) were similarly confounded: "Two paradoxes are evident from the early history of deer in West Virginia; one that they were reported to be abundant in virgin forests; the other that they nearly disappeared when heavy timber harvests began to stimulate an abundance of food and escape cover. . . . Virtual disappearance of the deer from most of the State coincided with the big timber-cutting years between 1880 and 1910." We should acknowledge, however, that because excessive market hunting took place concurrent with or just preceding removal of "old growth," it is difficult to separate the relative contribution of each to the deer decline.

In the West, Murphy (1879; as cited in Young 1956) gave similar pre-logging accounts of deer in great abundance and market hunting on a massive scale from the northern Rockies to the Pacific Coast. Gill (1976) and Wallmo et al. (1976) pointed out that there were no reliable estimates of deer populations in the Rocky Mountain region before or after the advent of extensive logging.

In the Pacific Northwest, Einarsen (1946), Cowan (1945, 1956), and Brown (1961) were perhaps most influential in legitimatizing the concept that "old-growth" forests supported few deer—despite Young's (1956:3) accounts of phenomenal market hunting along the Pacific Coast and in interior Oregon and Washington. Cowan (1945) arrived at deer density estimates of one deer per square mile (2.59 km^2) on the southwest coast of Vancouver Island. He did not present any data or describe how these estimates were derived, however. Later Cowan (1956:606) offered only one source of documentation—Einarsen's (1946) report of the response of deer to the Tillamook Burn in western Oregon. Later, Hine (1973), in summarizing a long-term study of deer in the Tillamook Burn, also offered only Einarsen's record of the early event.

Einarsen (1946:56-57) said, "This was originally a rugged area covered by a heavy stand of giant spruce, hemlock, Douglas fir, and cedar. . . . As a result of two severe fires, in 1933 and 1939, . . . the deer population was *reduced* [our italics] to less than one animal per section [square mile; 2.59 km^2] of land. . . . The area was closed to hunting until September 26, 1942. . . . During the protection period, deer increased from one to over 15 per section." There was no comment on the population density *before* the fire, or how any of the later estimates were obtained, or on the role that protection from hunting may have played in the increase.

Brown's (1961) verification of the reaction of deer populations to logging is limited to the results of pellet-group surveys conducted in southwestern Washington and the Olympic Peninsula in 1951. He measured four successional stages. His final successional stage consisted of "dense second-growth or mature old-growth timber areas that were considered to have a low productivity of deer forage" (Brown 1961:56). Because "old growth" and second growth were considered a single successional stage, it is difficult to evaluate the relative importance of "old growth'' as deer habitat especially since, on his intensive study area, true ''old growth'' was virtually absent (Brown, personal communication, 7 January 1981).

In our literature search we found few records of *measured* deer densities in ''virgin'' forest, but these were of interest because of their high levels. Hebert (1979:139) reported densities of Columbian black-tailed deer in previously unlogged forest on Vancouver Island: ''25–60 per square mile on a watershed basis'' and ''75–150 per square mile [on] specific winter ranges'' (10–23 and 29–58/km^2). Barrett (1979) estimated winter densities of 53 to 75 deer per square mile (20–29/km^2) on Admiralty Island in southeast Alaska. These estimates were based on pellet-group counts. Such estimates do not support the thesis that ''old-growth'' forest is poor deer habitat, but neither does the rest of the historical record. Furthermore that record does not provide reliable documentation of remarkable increases in deer populations attributable solely to the removal of ''old-growth'' forest.

There are only limited records and some photographs of the structure and composition of remnant stands of Eastern ''old-growth'' or virgin forests. To our knowledge, there were few, if any, deer studies in such forests. Moreover, many of the ''old growth'' forest ecosystems of North America had been greatly reduced before there was an intellectual discipline capable of interpreting them. The term ecology was not even coined until 1869, and the science was not formalized until around the turn of the century. The concepts of wildlife management, biotic communities, and succession developed thereafter (Leopold 1933, Allee et al. 1950). The simplistic notion that logging and timber management are ''good'' for deer, at least, seems to have come about more through a speculative process than through objective evaluation of data.

Forest Ecology

On the preceding pages, we have made a point of setting the term old growth in quotation marks, because it is used so indiscriminately. In the field of silviculture, old growth refers to forests that have reached the plateau of volume increment or, even, to an earlier age beyond which maximum economic return per rotation interval declines. But, those distinctions apply to managed forests, and much of the timber harvesting on this continent, to date, has consisted largely of first entries into unmanaged forests. So, for convenience in classifying that resource, the U.S. Forest Service applies the term old growth to stands older than some arbitrary age; in the Northwest it is 150 years. For the purposes of interpreting wildlife ecology, this definition is not adequate.

Silvicultural systems fall basically into two classes, even-age and uneven-age. The former takes advantage of the most common pattern of secondary succession. When old growth is completely removed by clearcutting, wildfire, or other agents, the trees that regenerate are all of about the same age. They tend, then, to grow apace toward the ''green-up'' stage, when their developing crowns have formed a more or less uniform canopy. As the trees continue to grow, each needs more space, and competition overcomes the weaker trees, but the stand retains its even-aged character (Figure 1). This is the aggradation phase, described by Bormann and Likens (1979), during which biomass increases more or less steadily to a maximum.

From the standpoint of timber production, it is most efficient to harvest at or below maximum biomass for it is followed by a transition phase of declining volume as growth of individual trees slows down and some succumb to disease, insects, or windthrow. Over a long period of time, perhaps centuries in spruce-hemlock forests of Alaska (Harris and Farr 1974), the forest reaches a point at which the standing crops of living, and total biomass begin to oscillate about a mean. According to Bormann and Likens (1979:174,175) an ecosystem in this dynamic but relatively unchanging condition can be labeled a "Shifting-Mosaic Steady State," which structurally, "would range from openings to all degrees of stratification. . . . The forest stand would be considered all-aged and would contain a representation of most species, including some early successional species, on a continuing basis."

Although there may be no immediate reason for the timber manager to preserve the Shifting-Mosaic Steady State, it has some important characteristics for wildlife. In southeast Alaska, for example, most of the forest exists in this uneven-age stage (Figure 2), and as such, exhibits high structural complexity and variability in both a vertical and horizontal plane as compared to second-growth stands. In areas of recent disturbance, or where older trees have fallen, herb and shrub communities occupy the openings, or thickets of saplings may develop. Wet or rocky sites, or areas subject to soil sliding may remain permanently brushy. With trees of a wide

Figure 1. This second-growth forest in southeast Alaska is about 150 years old. It is even-aged, silviculturally mature, and has low habitat diversity compared to old-growth forest.

age span, the forest has a multi-layered canopy. Thus, in the vertical plane, the structure of the community includes an herb layer, shrubs varying from a few inches (cm) to over 6 feet (2 m) in height, sapling-size and pole-size trees, and subdominant and dominant trees many centuries old with crowns ranging from, perhaps, 100 to 200 feet (30-61 m) in height. Fallen trees in various stages of decay, standing dead trees ("snags"), and a variety of epiphytes, including mistletoe, fungi, mosses and lichens, add to this vertical complexity.

Even-age silviculture stops development at or below the end of the aggradation phase when forest structure is comparatively simple. At that stage, in most coniferous forest types, vertical structure consists of the forest floor stratum, mostly devoid of vascular plants, an intermediate stratum of even-aged, even-sized, more or less evenly distributed tree trunks, and a dense, one-layered canopy. Obviously, there is much less structural complexity and variability (i.e. diversity) in such a stand compared to old growth. In Alaska, this condition persists for close to two centuries following clearcutting (Alaback unpublished report, Harris and Farr 1974, Wallmo and Schoen 1980). It is the kind of "mature forest" illustrated by Cowan (1956:566) as an example of poor deer habitat in the Pacific Northwest. Bormann and Likens (1970:170), in reference to the northern hardwoods, state: "Interestingly, it seems in the minds of many novelists, conservationists, foresters,

Figure 2. This old-growth forest in southeastern Alaska is uneven-aged, silviculturally overmature, and has high habitat diversity compared to second-growth forest.

and ecologists this type of massive, more or less even-aged successional forest is equated with 'virgin,' 'climax,' 'pristine,' or steady-state forest.''

In the remainder of this paper, the term old growth will be used to refer to forests that have reached the ''shifting-Mosaic Steady State.'' This concept says more about the potential biotic community than the term climax.

Wildlife Ecology

The importance of old growth to many species of wildlife remains largely unstudied and poorly understood. We intend to direct our primary focus here to one subspecies, Sitka black-tailed deer *(Odocoileus hemionus sitkensis),* which we have had recent opportunity to study in a true, steady-state, old-growth forest in southeast Alaska. Our investigations revealed that these deer used old-growth forest considerably more in both summer and winter than any seral stages from 1 to 150 years of age (Schoen and Wallmo 1979, Wallmo and Schoen 1980, Schoen et al. 1981a). Other researchers in southeast Alaska revealed that relatively shallow snow and an abundance of available forage are among the reasons for this preference in winter (Bloom 1978, Barrett 1979). In comparison to old-growth forest in Alaska, even-aged, second-growth stands (30-150 years old) produce minimal understory forage. Recent clearcuts (3-20 years old) produce abundant forage but snow accumulation during winter periods often makes this forage unavailable to deer.

Encouragement that our observations of the importance of old growth were not anomalous comes from studies of Columbian black-tailed deer *(Odocoileus hemionus columbianus)* which have exhibited similar responses. In British Columbia, it has been suggested that clearcutting in the hemlock-spruce climax would not improve game production (Robinson 1958) or benefit deer populations (Gates 1968) due to reduced range quality associated with rapid succession. On Vancouver Island, Jones (1974, 1975), Weger (1977), and Harestad (1979) obtained data supporting the importance of old-growth forests as winter deer habitat. The results of these British Columbia studies were reiterated and emphasized further by Bunnell and Eastman (1976), Cowan (personal communication, 2-13-78), Bunnell (1979), and Hebert (1979). Hebert (1979), in addition, presented evidence of deer declines, following logging of old growth on Vancouver Island, of as high as 75 percent. He indicated that declines as great as 80 to 90 percent may be expected.

In eastern North America, the effect of snow in reducing white-tailed deer *(Odocoileus virginianus borealis)* use of clearcuts has been described by Krull (1964) in New York and by Drolet (1978) in New Brunswick and Nova Scotia. Mundinger (1980) reported the same for northwest white-tailed deer *(Odocoileus virginianus ochrourus)* in western Montana, and he recommended a 250-year timber harvest rotation to retain suitable forest for winter habitat.

Numerous graphic models have been presented to illustrate the value of sequential stages of forest succession as deer habitat (e.g., Leopold 1949, Brown 1961, Mohney 1976, Lowe et al. 1978, Wallmo and Schoen 1980). They are based on many reports of increases in potential forage supplies and deer use levels in young clearcuts or burned areas relative to adjacent forest. None of these models, except that developed by Wallmo and Schoen (1980), carry the theoretical results to the ultimate stage of uninterrupted succession. When considering deer response to forest succession, it is important to adequately evaluate the entire chronological sequence of succession. In Alaska, the effect of cutting an old-growth stand is to increase for a short (15-20 year) period understory *productivity,* recognizing however, that understory *availability* may actually decline due to excessive snow accumulation in these openings. This is followed by 80 to 85 years (on a 100-year rotation) of relatively nonproductive second growth. The net result for deer is a decline in carrying capacity over the entire rotation.

In southeast Alaska, we have only begun to study how deer respond to certain characteristics of their old-growth environment (Schoen et al. 1981a). Many other wildlife-habitat relationships, with respect to old growth, will require review and further study. Lacking these data, one might safely assume that a goal of maintaining the greatest wildlife diversity (i.e., variety) is more a matter of maintaining the greatest habitat diversity. This relationship has been discussed generally by Odum (1971) and Ricklefs (1973), and is perhaps best demonstrated by the numerous studies correlating bird species diversity with habitat diversity (MacArthur and MacArthur 1961, MacArthur 1965, Balda 1975, Shugart et al. 1975, Meslow 1978, Anderson et al. 1979, Mannan 1980, and others).

Ecologists generally believe, with some exceptions (Whittaker 1970, Ricklefs 1973), the diversity and complexity of community organization increases with succession (Whittaker 1970, Odum 1971, Ricklefs 1973). In southeast Alaska, it is readily apparent that habitat diversity in the old-growth, or climax stage of succession (e.g., Figure 2) exceeds that found within early or intermediate successional stages (e.g., Figure 1). A conceptual model of a few seral relationships within the forest ecosystem of southeast Alaska is presented in Figure 3.

In the Pacific Northwest, old growth is considered an optimal or essential habitat for some bird species (Meslow and Wight 1975, Meslow 1978, Forsman et al. 1977, Bull 1978).

In discussing breeding bird diversity and vegetative structure, Balda (1975) stated, "Until we have the necessary information on specific habitat types on a regional basis a goal of land managers should be to maintain as many naturally occurring habitats (especially climax communities) as possible. . . . "

Luman and Nietro (1980) listed several wildlife species in the Pacific Northwest whose complete or partial dependence upon old growth is such that preservation of their present populations may require the retention of large areas of old-growth timber. They included the northern spotted owl *(Strix occidentalis caurina),* goshawk *(Accipiter gentilis),* pileated woodpecker *(Dryocopus pileatus),* Vaux's swift *(Chaetura vauxi),* marten *(Martes caurina),* fisher *(Martes pennanti),* northern flying squirrel *(Glaucomys sabrinus)* and red-backed vole *(Clethrionymys californicus).*

Some species that may not have primary dependence on old-growth forest throughout their geographic range have been observed to utilize it seasonally, and may be dependent upon it in some areas at some times. Examples are moose, *Alces alces* (Doerr et al. unpublished manuscript), mountain goats, *Oreamnos americanus* (Schoen et al. 1981b), black bears, *Ursus americanus* (Kelleyhouse 1980), grizzly bears, *Ursus arctos* (R. D. Mace, personal communication and in press), white-tailed deer, *Odocoileus virginianus* (Mundinger 1980), and Vancouver Canada geese, *Branta canadensis fulva* (Lebeda 1980).

The Vancouver Canada goose is interesting because of its remarkable departure

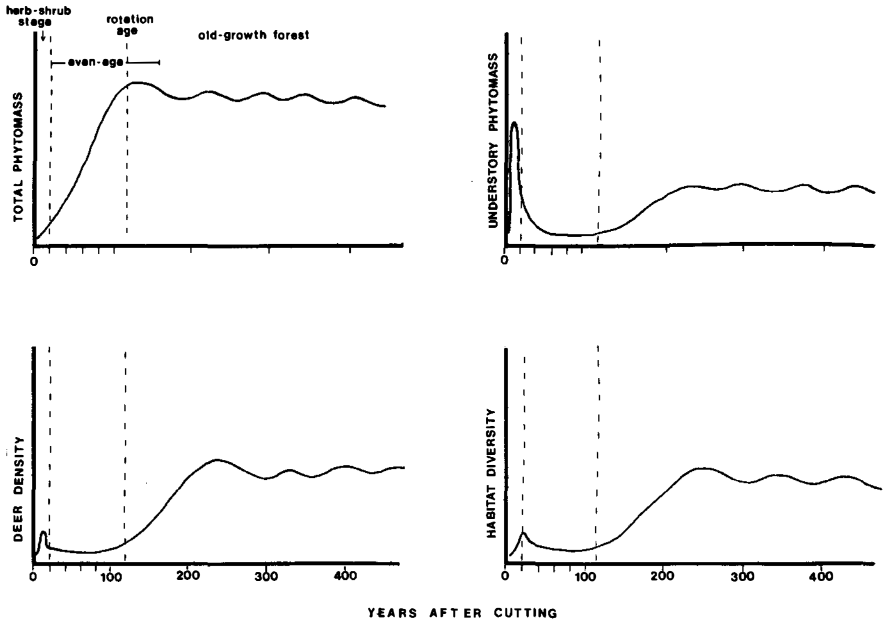

Figure 3. Conceptual models of several seral relationships within the forest ecosystem of southeastern Alaska.

from typical habitat use by the species. On Admiralty Island in southeast Alaska, their preferred habitat for nesting and early brood rearing was found to be old-growth forest (Lebeda 1980). Also in southeast Alaska, which has the largest population of bald eagles *(Haliaeetus leucocephalus)* in the United States, nesting habitat of bald eagles consists almost exclusively of old-growth forest usually within close proximity to the marine shoreline (Robards and Hodges 1976).

It is significant that many of the examples of old-growth use by wildlife are taken from the Pacific Northwest or southeast Alaska because this area is the last stronghold of extensive, though rapidly diminishing, old growth left in the United States. Here, opportunities are still available to observe natural phenomena that have long disappeared over much of the continent. In North America, generally our understanding of early seral ecology is much more complete than that of old-growth forest ecology for the reason that relatively few ecologists have studied or have had the opportunity to study the biotic communities of true old-growth forests. We have been able to cite only a few examples of the value of old growth to some wildlife species. It is regrettable that the interest developed so late, because such habitat may be disappearing faster than we can develop an adequate understanding of it.

Conclusion

The diverse goals to which wildlife managers are responding today require a better process than is currently used for integrating wildlife and forest management. Thomas (1979) has offered the first realistic attempt to face up to the enormity of that charge, and his planning system has been widely acclaimed as a means for providing responsible multiple use management of forest lands. However, as we develop new approaches for integrating wildlife goals and objectives into forest management, we must ensure that such guidelines are based on current quantitative data and are applicable to the area in question. We must also be cautious in our application of generalities and keep in mind that "Progress in any field may be measured by the rate at which generalizations are broken down and reformulated" (Leopold 1930:332).

Our purpose here has been to point out the scarcity of old growth in North America today, and to draw attention to the need for a greater understanding of the role old growth plays in wildlife-forest relationships. Old-growth forests are today very limited and, under standard rotations, nonrenewable. Thus our approach to forest management of old growth will have substantial and long-term consequences. The magnitude of our responsibility is well stated by Juday (1976:158) who cautioned that "despite the enormous temptation of great economic gain from the sale of old-growth timber, resource managers must always remember that old-growth is a phenomenon that pre-dates them and the human species . . . It functions according to rules that the human species must understand if we are truly serious about managing forest ecosystems on a long term basis." More research and less speculation will be required if we are to meet our responsibilities in providing enlightened and knowledgeable wildlife-forest management.

Acknowledgments

Many individuals have contributed ideas, information, and critical review toward our efforts in preparing this manuscript. We would especially like to thank Jack Lentfer, Nathan Johnson, Don McKnight, Tom Hanley, John Thilenius, Don Schmiege, Al Harris, Lars Holton, and Sterling Miller for their ideas and criticism and Karen Wiley for her technical review.

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REGISTERED ATTENDANCE

ALABAMA
Raymond D. Moody

ALASKA
Layne Adams, Peter J. Bente, William A. Gossweiler, Calvin J. Lensink, Donald E. McKnight, Pete Mickelson, Robert W. Phillips, William A. Quirk, John A. Sandor, John W. Schoen, Keith M. Schreiner, Ronald O. Skoog, Ronald J. Somerville, Daniel Timm

ARIZONA
Sally E. Antrobus, Bob Jantzen, Charles F. Roberts, Jon Rodiek

ARKANSAS
Harold E. Alexander, David Cameron Miller, Carlton N. Owen, Steven N. Wilson

CALIFORNIA
David R. Brower, Lewis R. Davis, Jerry Emory, Win Green, Ronald B. Hulberg, Jennifer May Langner, Cerena West Langner, Philip Leitner, William H. Marshall, Dale R. McCullough, Dennis G. Raveling, Hal Salwasser, William E. Talley, Richard Teague

COLORADO
Delwin E. Benson, Charles H. Callison, Jerry Claassen, Eugene Decker, Zakaria Abd El-Hamid, Jill Fredston, Bruce Gill, Jack R. Grieb, Eric G. Halverson, Michael K. Higbee, Thomas W. Hoekstra, Robert L. Hoover, Clinton W. Jeske, Eugene C. Knoder, Bruce L. McCloskey, Steve Mealey, Harvey W. Miller, Don W. Minnich, Pauline D. Plaza, Paul C. Purdy, Sally Ranney, Gail Shellberg, Gustav A. Swanson, Elroy Taylor, Joe Townsend, Robert K. Turner, Dale L. Wills

CONNECTICUT
John M. Anderson, Gene Blaine, Robert Hollister Davis, Susan J. Fitch, J. P. Glas, Anne Semmes Groo, Harry L. Hampton, Stephen Kellert, Jennifer Lewis, J. P. McAndrews, Jack S. Parker, Kenneth P. Placko, Daniel H. Pletscher, Michele T. Reis

DISTRICT OF COLUMBIA
Dave Almond, Irwin Alperin, Natasha Atkins, Steve F. Baima, John C. Barber, Eileen Barthelmy, Michael J. Bean, Bianca Beary, Mike Berger, Jack H. Berryman, Hugh C. Black, Karine Bogart, Curtis Bohlen, Janet Bohlen, LTC George F. Boone, Charles L. Boothby, Shirley Briggs, Jeffrey Brotnov, Gordon Brown, William Brown, John D. Buffington, Galen Buterbaugh, Martha Canan, Bob Carlton, Forrest Carpenter, Gail Chmura, Louis S. Clapper, Henry Clepper, Virginia Coull, John Crawford, Rod Cupka, Paul Cuplin, Richard N. Denney, Helen Doeding, Nicole Duplaix, Mary Lee Edwards, Peter Escherich, Scott Feierabend, James D. Felkel, Rebecca Field, Russell Fielding, Edward O. Ganstad, Tom Garrett, Roy Gordon, Pam Gring, Ellen Guerin, Victoria Guerrero, Michael L. Hall, Carole Hamilton, Sandy Hamilton, Elizabeth Harrington, Norma O. Hauanio, Wesley F. Hayden, Keith Hay, Michael Heller, John D. Helm III, Harry Hodgdon, Edward A. Hogan, Robert F. Hutton, Tim Irwin, Destry Jarvis, Mrs. Destry Jarvis, Joseph R. Jojola, Dale A. Jones, Lois Jones, Al R. Jonez, Philip Kopper, Karl R. Kranz, Robert M. Lake, Maurice Le Franc, Alan M. Levitt, Laura Loomis, Susan G. Loth, Thomas E. Lovejoy, Charles M. Loveless, Barbara Lundrigan, Linda Lyon, Raymond W. Matheny, John Mattoon, Robinson McIlvaine, Jerry P. McIlwain, Linda McMahan, Elizabeth Meer, Tom Melius, Mary Meloch, Melissa Merson, Lyn Mortimer, Charlie Most, Hans E. Nel, Bob Nelson, Jim Norine, Hal O'Connor, Richard M. Parsons, Carol Peddicord, Pete Petoskey, R. Max Peterson, Phillip C. Pierce, Doug Pifer, James R. Plautz, Paul C. Pritchard, James W. Pulliam, Jr., Bill Radtkey, Dennis Rankin, William K. Reilly, Rexford A. Resler, Leona Resler, Ed Roberts, John P. Rogers, Neil Sampson, T. R. Samsell, Robert Sanford, Christine Schonewald, Dan Seibert, Gerald D. Seinwill, Mark Shaffer, Napier Shelton, Thomas N. Shiflet, Rollin Sparrowe, Mike Spear, Elvis J. Stahr, Dana Stefenson, Beverly Strassmann, Richard Stroud, Genie Stroud, Carl H. Thomas, Mary Thomas, Frank H. Thomas, Richard S. Thorsell, Russell E. Train, Craig Tufts, Cindy Van Duyne, Keith Van Ness, Noreen Viering, Michael Wright

FLORIDA
Earl C. Anderson, Elsie R. Anderson, Robert M. Brantly, Michael W. Collopy, Walter F. Crissey, Mrs. Walter F. Crissey, Allan C. Egbert, Albert G. Hall, Florence B. Hall, Ronald F. Labisky, Richard L. Lattimer, Jeff Lincer, Wayne R. Marion, Frank Montalband, Joan Scott, Don A. Wood

GEORGIA
Harold W. Benson, Kenneth E. Black, Marjorie J. Black, Frank A. Hayes, Randall C. Long, Walter Stieglitz

HAWAII
Wayne C. Gagne, Steven L. Montgomery

IDAHO
Ernest D. Ables, Jerry M. Conley, Philip L. Lee, Xiao Qianzhu

ILLINOIS
T. Stanton Armour, Jean R. Armour, George V. Burger, Jeannine Burger, Mike Conlin, Matthew B. Connolly, Jr., Wesley M. Dixon, Jr., George B. Fell, Robert W. Guth, W. D. Klimstra, Miriam Klimstra, Edward L. Kozicky, Richard W. Lutz, Gloria M. Lutz, Kenneth V. McCreary, Jim Mick, Thixton Miller, Edward M. Puls, Richard Reinauer, Lee Roy Rendleman, Glen C. Sanderson, J. Henry Sather, John E. Schwegman, William L. Searle, Sally B. Searle, James M. Shepard, Kimberly Smith, David Tazik, Jeffrey K. Towner, John E. Warnock, Dale E. Whitesell

INDIANA
Robert D. Feldt, Bob Kern, Laura Kern, Charles M. Kirkpatrick, Gail Kirkpatrick, Fred Widlak

IOWA
Bob Barratt, Mary Cummings, Don Cummings, Robert B. Dahlgren, Allen L. Farris, Larry J. Wilson, Megan Epler Wood

KANSAS
Thomas A. Eddy, George C. Halazon, Bill Hanzlick, Lee Queal

KENTUCKY
Gail J. Barels, Joe Bruna, Peter G. Davis, David L. Erickson, Carl E. Kays, William McComb, Ginger A. Murphy, Nancy J. Sferra, Molly W. Rudersdorf, Ward J. Rudersdorf, Pete Thompson

LOUISIANA
Joe L. Herring, Jacob W. Lehman, Edith E. Lehman, Bob Stewart, Philip J. Zwank

MAINE
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